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ON THE PHENOMENA OF PROPAGATION OF MOVEMENT IN MIMOSA PUDICA.

BY

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On the Phenomena of Propagation of Movement in Mimosa pudica.

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In one of the most recent English works on Vegetable Physiology[1] the author expresses himself as follows in regard to the question of the propagation of movements in *Mimosa pudica* and similar plants :—

"It appears from these considerations that the theory which regards the transmission of a stimulus as a mere propagation of a disturbance of hydrostatic equilibrium is not satisfactorily established The theory is altogether too purely mechanical to account for so remarkable a phenomenon in a living organism, and we must endeavour to establish for it some other explanation which, while borne out at least as fully by the facts, will be more in harmony with our conceptions of the organisation of living beings."

An attempt is next made to show that such an explanation is to be found in the continuity of the protoplasm throughout masses of vegetable tissue forming tracks for the propagation of irritation from one organ to another.

The object of the following pages is to show that this theory is by no means as fully borne out by the facts as that for which it is substituted, and that there is a great mass of phenomena which, however they may conflict with current conceptions regarding organisation, clearly indicate that fluctuations in fluid tension, acting along with structural peculiarities of different masses of tissue, are the principal, if not the sole, cause to which propagation of movement must be ascribed. Details of such phenomena will be found in the tables showing the results of a very extensive series of experiments on the movements in *Mimosa pudica,* and they appear to me to justify the following theses .—

I. *The degree to which propagation of movement occurs runs parallel with the degree to which facilities for the extension of fluctuations in the fluid tension of the tissues are present.*

II. *The direction in which propagation of movement occurs is in many cases that in which the occurrence of fluctuations in the fluid tension of the tissues can be shown to occur, whilst it cannot be accounted for as the result of protoplasmic conduction.*

III. *The order of events in instances of propagation of movement is in*

[1] Lectures on the Physiology of Plants. By Sydney Howard Vines, M A , D.Sc., F.R.S., Cambridge, at the University Press, 1886.

many cases inexplicable on any theory of continuous propagation of protoplasmic irritation, while it is readily explicable as the result of fluctuations in fluid tension acting upon masses of tissue of different structural characters and holding different relations to surrounding parts.

Proceeding to the consideration of each of these in order, we have first to examine into the evidence in favour of the first. In doing so data might be derived from almost every table, but in the first place special attention is invited to those in Tables I to VII, showing the results following section and heating of distal pinnules, to those in Table VIII, showing the results of simple mechanical stimulation, and to those in Table IX, showing the phenomena attending mechanical obstruction to depression of the petiole on action of the primary pulvinus.

Table I is a general table of the results of experiments carried out at different times of year and under various conditions of temperature and atmospheric and telluric moisture. It includes details in regard to 100 cases of section of the tips of distal pinnules. The movements resulting from the injury were in 94 cases limited to the injured leaf, and in only 6 did they extend to one or more other leaves on the axis. In regard to 84 cases it is recorded whether the leaf was exposed to direct sunshine or was in shade at the time of section. In the 45 cases in which the leaf was exposed to the sun, action extended over the entire leaf in 41 instances, and in some extended to one or more other leaves. In the 4 cases in which the extension was not complete the tip of one pinna failed to act in one, an entire pinna in two, and one pinna and the primary pulvinus in one. In the 39 cases in which the leaf was in shade at the time of section action failed to extend over the entire leaf in 38 cases, being in 31 limited to the injured pinna alone or to it and the primary pulvinus, in 6 cases extending incompletely to other pinnæ and in one case only extending completely throughout the entire leaf.

Table II shows the results of section of distal pinnules of leaves in shade shortly after a fall of rain. It includes details regarding 20 experiments. In no single case was there any extension of movement beyond the injured leaf; in 10 cases action was limited to the injured pinna or to it and the primary pulvinus, and in the remaining cases it was never complete throughout the entire leaf.

Table III shows the results following section of distal pinnules of leaves in shade after a continuous period of heavy rainfall. It includes data of 10 experiments. Here, again, in not a single instance was there any extension of action beyond the injured leaf. In 6 cases action was limited to the injured pinna or to it and the primary pulvinus, and in all of them the action in the cut pinna was incomplete. In none of the 4 cases in which action extended to other pinnæ than the injured one was it complete or even well developed in them.

Table IV contains the results of 29 experiments on section of pinnules in different parts of pinnæ in leaves in shade. All of them were conducted on one morning, after a night in the early part of which there had been a heavy fall of rain. In none of them was there any extension of action beyond the injured leaf, and in none was the action in the latter complete.

Table V shows the results in 15 experiments on dry[1] leaves fully exposed to direct sunshine. Here, in 13 cases, the action was complete throughout the injured leaf, and in one of them it extended to another leaf. In the two remaining cases it extended to all parts of the leaf, but was not complete.

Table VI contains the details of results in 40 experiments, conducted under various external conditions, in which heat was applied to the extremities of distal pinnules. In only 6 of them was there any extension of action beyond the leaf primarily affected. In 34 cases it extended over the whole of the primarily affected leaf. In the remaining 6 cases in which the action was limited to the primarily affected leaf, action failed in the primary pulvinus in 2; in the others action occurred in the primary pulvinus but failed to extend completely over the remaining pinnæ.

Table VII shows the results obtained in a series of 10 experiments on the action of heat on the distal pinnules of leaves of dry plants.[1] Here, in 7 instances, action was extended to one or more leaves on the axis besides the one originally affected, and in the remaining 3 cases the action in the leaf was complete throughout in two and almost complete in the third.

In Table VIII the results of 3 distinct sets of experiments on the effects of influences producing movement apart from any abnormal discharge of fluid from the tissues are detailed. It relates to 30 experiments. In 10 of these full depression of the petiole was induced by pressure on its upper surface, in 10 a similar effect was induced by impact on the undersurface of the primary pulvinus, and in the remaining 10 action in individual pinnules was induced by elevation or depression of their tips. In the first set of cases full depression of the petiole was unaccompanied by any further results in 9 cases; in one case slight action in the secondary pulvini occurred as a secondary phenomenon. In the second series slight action in the secondary pulvini occurred in two cases. In the third series the action was throughout purely local.

In Table IX we have the results obtained in 24 experiments, conducted on one morning, on the effects of section of the tips of distal pinnules of leaves, in which in 12 instances depression of the petiole was mechanically obstructed, while in 12 it was fully carried out. In the 12 cases in which depression was mechanically obstructed, the action in 9 cases was limited to the injured pinna and the primary pulvinus, whilst in those cases where it extended further it was

[1] The term "dry" is here used to indicate that the leaves were free from any visible adherent dew or rain.

extremely limited in its distribution. In the 12 cases where depression of the petiole was fully and freely carried out, action extended in various degrees to other pinnæ than that primarily affected in no less than 10 cases.

In regard to the two latter tables, it may possibly be affirmed that the limited number of the experiments detailed, and the fact that in each case they were conducted on a single occasion, detracts from the value of the data. To any such objection all that I can reply is, that the only reason why the details of a larger number of experiments conducted at different times have not been given is that it appeared to be undesirable to increase the bulk of the tables, already sufficiently cumbrous, by a mass of monotonous repetitions of identical results. It may, however, be as well to give a little further information in regard to the points specially dealt with in these tables. With regard to the effect of movements induced by the purely mechanical agency of pressure or impact apart from anything causing abnormal discharge of fluid from, or abnormal obstruction to, the access of fluid to the tissues, all that I can say is that, after having tried a very large number of experiments on the subject, I am fully convinced that they are invariably almost, if not absolutely, localised where the experiments are conducted under conditions such as those prevailing in Calcutta. By means of upward or downward pressure on the petiole or upward or downward pressure on the primary pulvinus, extreme petiolar depression may be certainly induced with an entire or almost entire absence of any further result.[1] By judiciously applied impulse, either all the pinnules of all the pinnæ alone, or all the pinnules of all the pinnæ and all the secondary pulvini may be caused to act without the faintest trace of action in the primary pulvinus. Finally, by applying upward or downward pressure to individual pinnules in a pinna, absolutely localised movement in them alone may be secured, and to such an extent is this the case that numerous isolated pinnules on both sides of one and the same pinna may be caused to act without any propagation of movement either centripetally, centrifugally, or transversely.

With regard to the phenomenon of minor extension of action in leaves where there is a prevention or diminution of the petiolar depression consequent on action in the primary pulvinus, it may be stated that the experiments tabulated are merely given as showing the results constantly observed in other cases in which obstruction either occurred naturally due to the relation of the leaves and axes in dense masses of the plant, or was artificially induced by means of ligatures confining the petiole more or less completely to its erect position.

So much for the general results of the tabulated experiments, but we have now to consider their bearing on the question of the cause of the propagation of movement from one part to another of the plant. At the very outset there is

[1] The phenomenon of further action where it does occur may be best considered in connection with the events recorded in Table IX.

one thing which cannot fail to strike any one who is in any degree acquainted with the subject, namely, that in the experiments in regard to which details are here given, the extension of the action under the influence of so-called stimulant agencies, such as section and heat, is curiously limited as compared with what it would appear to be in Europe according to the ordinarily accepted authorities. Now, there can be absolutely no doubt that this limited extension is the normal phenomenon in plants grown in the open ground in Calcutta under similar conditions to those to which the plants of the experiments were exposed. But if this be so, the difference in degree of propagation of movement in Calcutta and Europe must be due either to differences in the degree of irritability, conductivity or contractility of the protoplasm of the tissues, or to the presence of differences in degree of conditions favouring the occurrence of fluctuations in degree of fluid tension throughout the tissues. According to the former view it must be assumed that in the plants in Calcutta growing in the open ground and under conditions so favourable as to lead them to run wild and assume the character of troublesome weeds, the protoplasm is less irritable, or less conductive or less contractile than it is in pot-plants in European laboratories and conservatories. The necessities of the theory remain, however, the sole ground for any such assumption. On the other hand, on the view that the propagation of movements is essentially due to extension of fluctuations in tension of fluid in the tissues, an explanation of the phenomenon is ready at hand. In plants growing as they do in Calcutta, the facilities for rapid and extensive root absorption must be much greater, and the tendency to loss by evaporation much less than in plants with roots confined within limited areas of soil in pots and exposed to the relatively dry air of laboratories or conservatories.[1] Any interference giving rise to abnormal escape of fluid from the tissues either as the result of ruptured continuity as in cases of section, or of diminished capacity to retain fluid, such as is apparently present (*vide* page 95) in cases of heating, must almost inevitably give rise to movements, the extension of which over larger or smaller areas of the tissue will be proportionate to the facilities for rapid removal of fluid from the site of escape and for a renewed supply to make good the loss. In plants under conditions such as those prevailing in Calcutta we should expect, then, to find, what we actually do find, that extensive propagation of movement is a rare phenomenon as compared with what it is in European plants. It appears thus that in this instance the theory of propagation of movement as essentially dependent on protoplasmic continuity fails to furnish an explanation of a phenomenon readily explicable by the other view, and that this phenomenon is one indicating that the extension of movement is proportionate to extension of fluctuations in fluid contents of the tissues.

[1] In Calcutta, as in the lower parts of the Gangetic delta generally, we have to deal with an area in which the soil is at all times saturated to within a few feet of the surface, the atmospheric humidity constantly high and frequently excessive, and the rainfall great.

Taking the data in the separate tables, we find additional evidence of this in the following phenomena. In Table I there is evidence to show that the extension of movement is related to exposure to sunshine or shade, the tendency to extension being, under otherwise like circumstances, much greater under the former than the latter condition. But exposure to direct sunshine is certainly exposure to increased evaporative loss of fluid. This, of course, needs no demonstration, but if it did, an examination of the condition of the leaves of any mass of the plant, before and after it has been exposed to direct sunshine, ought to be sufficient to meet all requirements. In a vigorous mass of the plant growing under favourable circumstances, we find that it is in the early morning, and whilst the leaves are still moist with dew, that the condition of expansion is at a maximum. As the sunshine strikes on it, and as the leaves gradually lose their adherent moisture, we find that the expansion tends to diminish, and, under continued exposure, in many cases becomes very conspicuously less than it was. Not only do we find slow, insensibly progressive movements taking place under the influence of the sunshine, but, under certain circumstances, rapid, large movements occur similar to those resulting from so-called stimulation of the tissues. If a mass of the plant be carefully watched just as it is struck by the sunshine, such movements can frequently be observed to take place in large numbers. Especially conspicuous are those taking place in the case of young, terminal and only partially-expanded leaves situated at the tips of axes. These are, as a rule, so long as the plants remain in the shade, in a condition of extreme erection, but after a brief exposure to the sunshine in many instances, quite apart from any other appreciable exciting cause, become suddenly depressed, due to action of their primary pulvini and depression of the petioles. Similar movements may also be seen to occur, under like circumstances, in other portions of the leaves. They appear often very conspicuously in the case of leaves in a condition of partial recovery from the effects of application of heat to distal pinnules. Recovery in such cases usually commences with elevation of the petiole, followed by divergence of the pinnæ, and gradual centrifugal expansion of the pinnules. In leaves in which recovery has advanced so far in the shade that the basal pinnules have begun to diverge, the access of direct sunshine is often followed almost immediately by movements of relapse in varying degree, in some cases confined to the pinnules or secondary pulvini, but in other cases complete and involving the primary pulvinus and leading to renewed petiolar depression. Similar phenomena present themselves in the case of the leaves on detached branches kept in a saturated atmosphere beneath bell glasses, if the latter be carefully removed and direct access of sunshine permitted.

Exposure to direct sunshine implies increased facility for evaporative loss, and we find from the experiments that it also implies increased tendency to extension of movement. The theory that extension of movement is

dependent on protoplasmic continuity must assume that the sun's rays elevate the irritability, conductility, or contractility of the protoplasm without affording any evidence that they actually do so, the other theory can point to direct evidence of increased facility for evaporative loss and therefore increased facility for extension of fluctuations in fluid content of the tissues running parallel with increased tendency to extension of movement.

The table not only contains evidence of the association of increased tendency to extension of movement with exposure to conditions favouring loss of fluid from the tissues, but further a certain amount of direct evidence of the association of special limitation of extension with the presence of conditions favouring supply of fluid to, and obstructive to loss of fluid from, the tissues. In experiments 54 to 57 inclusive we have a set of cases in which the phenomena of movement in leaves in the shade and exposed to rain at the time of experiment are detailed. In every one of these cases we find that the phenomena of movement were extremely limited in their extension. In none of them did they extend beyond the injured pinna and the primary pulvinus, in two cases movement was confined to a limited number of pinnules, and in two more to a limited number of pinnules and to the primary pulvinus.

The next two tables (II and III) contain evidence of a like nature. They show the phenomena presented by leaves in the shade and after recent rainfall on section of distal pinnules. In both we have clear evidence of limitation of extension of movement, and there are even indications of a direct relation between the degree of limitation and the amount of moisture to which the plants were exposed. In the case of the experiments in Table II the plants had been exposed on the previous evening to heavy showers, while those in Table III were carried out after an evening and night of continued rain, involving, at all events, a greater supply of soil moisture, and in association with this we find indications of the presence of greater limitation in them than in the others. In Table II we have 20 experiments with limitation of action to the injured pinna or to it and the primary pulvinus in 10; in Table III we have 10 experiments with such limitation present in 6 cases.

According to the theory of the protoplasmic origin of extension of movement, we find now that it must be assumed, not only that sunshine raises the activity of the protoplasm in this respect, but that the addition of moisture lowers it. According to the other theory the phenomena differ from one another in the different instances, because of the presence of demonstrable differences in the facilities for loss and supply of fluid.

Table IV contains evidence of a similar kind to that afforded by the two previous tables. The series of experiments, the results of which are embodied in it, was conducted on a morning following a night in the early part of which there had been a heavy fall of rain. The morning was cloudless, but slightly hazy and the direct sunshine had not yet reached the plants. The leaves were

in a state of full expansion and had been thoroughly washed by the rain, but the amount of moisture adhering to their surfaces was trifling as compared with that present after any normal night of heavy dewfall. The extension of movement was in almost every instance very limited, in no case was it complete throughout the injured leaf, and in no case was there any extension beyond it.

The data afforded by Table V are to be regarded as supplementary to those in Table I, complementary to those in Tables II, III, and IV. We have here to deal with the phenomena presenting themselves in 15 cases of section of leaves from which the sunshine had already completely removed the adherent dew, but which were still in a condition of full expansion. The results contrast strikingly with those in the three previous tables. The extension of movement was much more considerable, complete movement occurring throughout the entire leaf in 13 cases, movement extending to all parts of the leaf in the remaining two, and an extension to another leaf on the axis occurring in one instance. We have here, again, evidence of the association of increased extension of movement with increased facilities for the occurrence of extensive fluctuations in the fluid contents of the tissues.

The data contained in Table VI show that the phenomena following the application of heat to distal pinnules only differ in degree from those following section. They show a distinct tendency to greater extension of movement, but that, under conditions such as those prevailing at the time of experiment, the extension was in any case comparatively limited, and in the great majority of instances was confined to the injured leaf. The 40 experiments, the results of which are embodied in the table, were, in the great majority of instances, conducted in the morning, and when the plants were still loaded with dew and not as yet exposed to direct sunshine, and, under these circumstances, we find that in only 6 cases was there any extension of movement beyond the leaf to which heat was applied. The results here contrast strikingly with those in the following table.

In this, Table VII of the series, we have to deal with 10 experiments. These were all conducted on a cloudy morning between 8 and 9 A.M., but before there had been any direct sunshine. The plants were in a state of full expansion, but the leaves were quite dry, there having been a minimum of dew deposited during the course of the previous cloudy night and no rain having fallen for 10 days previous. Under these circumstances, we find that the tendency to extension of action was manifestly increased, as in 7 instances action extended beyond the leaf primarily affected to one or more others along the course of the axis, and in every case the action, at all events, extended over the whole of the primarily affected leaf. Here the influence of direct sunshine as influencing protoplasmic activity is directly excluded, and on the protoplasmic theory we must assume that relative desiccation gives rise to augmentation of the protoplasmic activity of the tissues. As in the previous cases

however, there is no proof in support of this but the necessities of the theory; whereas the phenomenon is capable of serving as direct evidence in support of the other theory.

It may possibly be objected here that in cases of application of heat to pinnules there is no evident reason for the occurrence of abnormal loss of fluid to an extent corresponding to the ensuing phenomena of action, and no such manifest occurrence of escape of fluid as that taking place in cases of section in which the exudation of drops of fluid from the cut surfaces can almost always be readily recognised. The evidence that an abnormal escape of fluid does occur under the influence of heating of the tissues is, however, clearly afforded by Table X, in dealing with the details of which a further reference to this point is made.

The data contained in the next table, No. VIII, of the series are of a nature which it will be hard for the protoplasmic theory to account for. In them we find that where no abnormal escape of fluid from the tissues is connected with the so-called stimulation, there is an almost absolute localisation of movement to the area directly affected. The only exceptions to the localisation which I have observed are in certain cases where action of the primary pulvinus is primarily induced. In such cases a certain degree of subsequent action in the secondary pulvini or in the pinnules may occasionally be observed to occur. The occurrence of extension of movement in these cases, as the data in the next table will show, is, however, no evidence of the occurrence of any protoplasmic extension of activity, but is, on the contrary, to be accounted for as the result of obstruction to the normal fluid supply of distal parts connected with extreme flexion of conducting tissues. Advocates of the protoplasmic theory may possibly affirm that the extreme localisation of movement in cases of purely mechanically induced action is the result of a minor degree of stimulation of the tissues in such cases, pure mechanical impulses being less irritant than ruptures of continuity or thermal agencies. But are we to suppose that in cases where every pinnule and all the secondary pulvini have acted under the direct influence of pure mechanical impulse there has been less stimulation than when the tips of one or two distal pinnules alone have been divided or heated? According to the protoplasmic theory we must do so, as no extension of action occurs in one case and extension is the normal phenomenon in the other. Here, as in all the previous cases, the protoplasmic theory requires to be supported by the assumption of a hypothetical condition; whereas the other theory can point to the presence of an actual one to account for the phenomenon under consideration.

The data, embodied in Table IX, have been already alluded to in dealing with those of the previous one. They are those obtained from a series of experiments which were all conducted on one morning, but the results agree with those obtained on many other occasions so closely in regard to the

main phenomena that they may, I believe, be regarded as normal. They very distinctly indicate the existence of a direct relation between the degree of petiolar depression and the extension of movement. In cases where petiolar depression was fully carried out, we find that extension of movement was greater than in cases where petiolar depression was suppressed or obstructed. Now, it is very hard to see why the degree of petiolar depression should affect the protoplasmic activity of the tissue, so as to interfere directly with the extension of stimulation of the protoplasm. It is not as though the failure in petiolar depression in these cases had been due to failure in action in the primary pulvinus, for in all these cases the primary pulvinus acted and did its utmost to secure depression. But on the theory that extension of movement is a matter of extension of fluctuations in the fluid content of the tissues, we can readily explain the phenomenon, for in cases where full depression of the petiole is free to occur there is necessarily extreme flexion of the tissues of the primary pulvinus, and such flexion must imply obstruction to the onward flow of fluid from the axis in direct proportion to the degree which it attains. But in cases in which the abnormal facilities for escape of fluid induced by experimental interference are approximately alike, as they presumably were in the set of experiments referred to in the table, the resultant phenomena ought to be in proportion to the facilities for the supply of fresh fluid to the tissues. In those cases in which there is obstruction to such renewal of fluid, the extension of movement ought to be greater than in those where obstruction is absent, or is present in minor degree, and these are precisely the phenomena which we find actually presenting themselves to observation. The phenomenon of a certain degree of action in the secondary pulvini in some cases where action of the primary pulvinus and petiolar depression have been caused by means of purely mechanical agencies which are normally followed by purely localised action, finds its explanation here.

Taking the data in the tables which have now been considered as they stand, I believe them to show that while the protoplasmic theory requires a continuous series of assumptions to bring it into accordance with facts, the other theory derives direct support from them, and that the thesis of the parallelism of extension of movement with facility for the extension of fluctuation in the tension of fluid in the tissues is amply supported.

The evidence in favour of the second thesis, that the direction in which propagation of movement occurs is in many cases that in which the occurrence of fluctuation in the fluid tension of the tissues can be shown to occur, whilst it cannot be accounted for as the result of protoplasmic conduction, has next to be considered. It is principally contained in Tables X and XI, showing the phenomena occurring in cases of the application of heat to the course of axes and those following section of the tips of axes.

Table X contains details regarding the effects following the application of

heat to axes, the application in some cases being carried out by means of flame, in others by contact of heated metallic surfaces, and, in still others, by means of focussing the sun's rays on the surface with the aid of a lens. The general results were not in any case alike. There was always a more or less extensive propagation of movement along the course of the axis, but while in all cases centrifugal propagation manifested itself and, as a rule, was extensive, in only 18 cases was there any centripetal action, and in these of very limited extension only.

Table XI deals with the effects of section of the tips of axes in 38 cases in which the phenomenon of propagation of action manifested itself in various degrees of intensity, the extension being sometimes very limited, at others very widely diffused. In dealing with this table it must be pointed out that phenomena of propagation of movement are by no means necessarily present in every case of such distal sections. They do not by any means occur with the same constancy with which those following heating of axes occur. The table, therefore, is to be taken simply as illustrative of effects frequently following distal section, and not as illustrating an invariable phenomenon.

In proceeding to consider the bearing of the data in the first of these tables on the question of the causation of propagation of movement, the most striking phenomenon presenting itself to observation is that of the rarity and limitation of centripetal as compared with centrifugal propagation. In only 18 cases was there any centripetal propagation, and in 15 of these the action was limited to a single leaf, while in the remaining 3 cases it did not extend beyond two leaves. In the same cases centrifugal propagation manifested itself along the entire course of the axis beyond the point of application in 13 cases, and in the remaining 5 the amount of centrifugal extension exceeded that of centripetal action. In the remaining 50 cases in which centrifugal propagation alone manifested itself, movements took place in all the leaves along the axis beyond the site of application in 30 cases, and in the remaining 20 cases the propagation was, as a rule, relatively extensive, being only in 3 instances limited to a single leaf, and in the others manifesting itself in from 2 to as many as 14 leaves.

Now, how far are these phenomena explicable by the theory of propagation as the result of conduction of impulses along continuous masses of protoplasm? If they are to be explained by it, it is necessary to assume that the protoplasm has a greater conductive power centrifugally than centripetally, for it can only be as the result of this that propagation occurs so much more frequently and extensively in the centrifugal than in the centripetal direction. This difference in conductivity must, moreover, be very great to account for the great general differences in the degree of extension and for the frequency with which centrifugal action alone manifests itself, even where the site of application is very close to an inferior leaf and relatively remote from any superior one. But there is, so far as I am aware, absolutely no independent evidence in favour of any

such assumption, whilst there are many facts to show that it is quite untenable.

In the first place we have the phenomena presenting themselves in cases, such as those which are embodied in the earlier tables, of the occurrence of ready and certain centripetal propagation of movement under the influence of agencies acting on the terminal portions of leaves. These tables, moreover, not only demonstrate the facility with which centripetal action occurs, they also show that, under certain circumstances, it takes place more readily and fully than centrifugal action. On consulting the statement of results in experiments 21 to 29 of Table IV dealing with the effects following section of the tips of the central pinnules of pinnæ, it appears that centripetal action, as a rule, both preceded and was more complete than centrifugal action. The number of the cases cited is, no doubt, very limited, but the results may certainly be taken as typical of those occurring under like circumstances, and distinctly prove that there is no general tendency to centrifugal rather than centripetal action. If it be now objected that these experiments refer to leaves and not to axes, and that therefore they cannot be fairly cited as evidence in regard to phenomena manifesting themselves in the latter, the data in the table which has next to be dealt with afford a sufficient answer.

This table, No. XI of the series, contains details regarding 38 cases in which the tips of axes were removed by careful section, and clearly shows that very extensive centripetal action readily occurs under certain circumstances. In order, then, to explain the phenomena occurring in cases of the application of heat to axes, the protoplasmic theory must assume, not merely the presence of greater centrifugal protoplasmic conductivity, but also that the directional conductivity of the protoplasm is modified according to the nature of the influence which gives rise to movement, section of pinnules, or of the tips of axes giving rise to a greater amount of centripetal conductivity than the application of heat to axes is capable of doing. Here, again, the facts do not support the theory, but, on the contrary, necessitate the introduction of unfounded assumptions to bring them into accordance with it.

It now remains to determine how far the other theory accords better with the phenomena of excess of centrifugal propagation in cases of heating of axes, and at the same time of extensive centripetal propagation in cases of terminal section. There can, I believe, be little doubt that it does so. In dealing with the axes, we are dealing with a series of conducting channels along which fluid is constantly passing, the current being kept up due to constant losses of large amounts of fluid from the leaves and other distal parts and constant additions of fresh fluid from the roots. If now any abnormal agency give rise either to obstruction of such channels or to abnormal discharge of fluid from them at some point in their course, fluctuations in the amount of fluid and, therefore, fluctuations in the tension in the system of channels must be induced.

So far as abnormal escape of fluid is concerned it must tend to fluctuations of depression throughout the entire system, but specially beyond the point of escape. So far as obstruction is concerned, on the other hand, it must tend to the establishment of negative fluctuations over all the area beyond the site at which it occurs and of positive fluctuations over all centrally situated areas. Now, in cases of application of heat there is reason to believe that both obstruction and abnormal escape of fluid take place. The occurrence of an abnormal escape of fluid is readily appreciable in many cases, specially where the heating is effected by a condensation of the sun's rays on the axes. In all cases, whatever the nature of the procedure be, the primary effect of the application of heat is a discolouration of the epidermal tissue, which loses more or less the reddish tinge normal to it and becomes greener than the surrounding parts. In many cases where the sun's rays are the disturbing agent, the change, however, manifestly does not cease with this, as a conspicuous exudation of fluid, sometimes to the extent of forming a large drop, takes place, and a similar phenomenon occasionally manifests itself where the heating is effected otherwise. The tissue appears then to undergo such an alteration under the influence of heating as no longer to present sufficient resistance to the pressure of the fluids within it,—a pressure which is normally excessive, as the result of section or puncture of the axes clearly demonstrates.

The question remains how far the phenomenon indicates positive depression of resistance on the part of the tissue or relative depression due to local increase in pressure connected with obstruction? That such obstruction is present there can, I think, be little doubt, for the expansive effect of the elevation of temperature on the gaseous contents of the tissues must almost inevitably give rise to it in greater or less degree. As, however, a visible tendency to abnormal exudation manifests itself in minor degree in some cases of the application of heat to distal parts, such as the tips of distal pinnules, it appears probable that both agencies come into play in various degrees to give rise to the phenomenon in the axes.

But if obstruction and abnormal facilities for the escape of fluid be present in varying degree at a given point in an axis, what are the results which must obtain in any set of appendages such as the leaves which are maintained in their diurnal position by fluid pressure? Clearly they must lie in a tendency to assume the position characteristic of diminished fluid tension in all those areas where fluctuation of a negative character takes place. Now, in any case fluctuation of a negative character must take place distally, whether mere obstruction or mere abnormal escape or both together, are present, but this will not be the case on the central side of the site of development of the abnormal condition. Here the nature of the fluctuation will vary with the relations which conditions causing obstruction hold to those giving rise to facility for escape. Where the former conditions are present in relatively greater degree, the

fluctuations will be positive; where the latter prevail, negative, and, consequently, the effect on the leaves will not be constant as in the previous case, but in one case there will be an increased tendency to the maintenance of the diurnal position, in the latter a tendency to the assumption of the nocturnal one.

According to this the tendency to centrifugal propagation of movement ought to be greater than that to centripetal propagation, and this is precisely what we find to be the case as a matter of experiment. In the case of section of the tips of axes the conditions are different. Here we have to deal solely with conditions favouring abnormal escape of fluid,—conditions under the influence of which negative fluctuations are liable to be propagated centripetally much more constantly and in much greater degree than when conditions of obstruction, too, are present, and, in accordance with this, we find that much more conspicuous and extensive centripetal propagation of movement occurs in many instances in cases of section of the tips of axes than ever present themselves as the result of heating them in their course. There can, I believe, then, be little doubt that the theory which ascribes the propagation of movement to fluctuations in fluid tension is here, again, more in accordance with fact than that which regards it as due to a propagation of stimulation along the course of continuous protoplasm.

We have now to enquire into the evidence for the final proposition regarding the order of events manifested in many cases of propagation of movement. This is contained in Table XII, showing the results following the section of distal pinnules of young heavy leaves heavily loaded with adherent moisture. It shows that in 8 out of the 10 cases dealt with the primary pulvinus was either the very first part of the leaf to act or acted after the injured pinnules alone had moved. The number of experiments included in the table is small, but the results may be taken as typical for those in experiments conducted under like conditions. That this is so is rendered clear by the following data regarding the results of experiments carried out in regard to this point on three distinct mornings. On the first occasion, out of 204 leaves, 135 manifested such premature action in the primary pulvinus; on the second, out of 139 leaves 100 did so; on the third, out of 126 leaves 100 did so. The phenomenon to be accounted for by the theories of the causation of propagation is the discontinuity of action in such cases. According to the protoplasmic theory an explanation can only be arrived at by the assumption of special irritability or contractility in the protoplasm of the primary pulvinus, as compared with that in the other contractile organs. This special irritability or contractility must, moreover, be present in certain cases only, being very frequently present in young and moist leaves, and comparatively rare in old and dry ones, for the differences in the prevalence of the phenomenon in leaves differing in age and amount of adherent moisture is very conspicuous. On the same mornings on which premature pulvinar action occurred in 135 of 204 and in 100 of 139 young leaves loaded with adherent moisture, it only occurred in 11 out of 44 and 7 out of 61 old and

dry leaves. There is, however, nothing to show us that any such special irritability or contractility in the protoplasm of the main pulvinus exists at all or is specially related toage and moisture of the leaves.

When we come to consider the other theory we find that it can afford an explanation both of the occurrence of premature pulvinar action generally and of the greater tendency to such action in young and moist leaves than in old and dry ones. The primary pulvinus has more to contend against in maintaining the expanded condition than any other part of the leaf. The masses of tissue in it determining erection of the leaf have not merely to overcome the opposing thrust of those favouring depression, but have to overcome the downward leverage of the heavy pinnæ situated at the distal extremity of the long petiole. In the case of the secondary pulvini, which deal with lateral movements mainly, the resistance to be overcome is merely that of the opposed masses of tissue, in that of the tertiary pulvini, the action of the masses of tissue favouring expansion is aided by, not opposed to, the action of gravity. But under these circumstances the primary pulvinus must, under certain conditions, be liable to be affected by negative fluctuations in fluid tension incapable of giving rise to conspicuous effects elsewhere; or, in other words, the primary pulvinus, under certain conditions, is adapted to play the part of the most sensitive registering apparatus of the occurrence of fluctuations in the fluid tension of the tissues. Any conditions under which the thrust of the depressant pulvinar tissues is relatively excessive or the weight of the pinnæ abnormally great must tend to increase the sensitiveness of the apparatus. But in young and moist leaves such conditions are present in high degree. In the leaves of *Mimosa pudica* the tissue of the under-half of the pulvinus is relatively weakest when the leaves are young and becomes gradually stronger and more resistant with increasing age. So much is this the case in certain instances that it is not uncommon to meet with old but otherwise healthy leaves in which the primary pulvinus is rigid and petiolar depression accordingly impossible. This gradual increase in relative strength in the structurally weaker masses of pulvinar tissue is not peculiar to *Mimosa pudica.* Much more conspicuous examples of it are afforded by other plants, such as various species of *Bauhinia* and by *Albizzia Lebbek,* in which the young leaves exhibit highly-developed nyctitropic movements, which gradually diminish and ultimately absolutely disappear with increasing age and thickening and rigidity of the primarily passively weaker portions of the pulvinar tissues. The existence of such a change in the relative strength of the opposed masses of tissue accounts, then, for the greater prevalence of premature pulvinar movement in old than in young leaves, and the action of adherent moisture in increasing leverage accounts for its greater prevalence in wet than in dry ones.

The phenomenon of premature pulvinar action is not the only instance of discontinuity in propagation of movement presenting itself to observation.

Other examples frequently occur both in individual leaves and along the course of axes. Examples of such occurrence are contained in several of the tables; for example, in cases 91 and 92 of Table I, we have examples of discontinuous order in the action of the pinnules of individual pinnæ, in cases 6 and 8 of Table VII we have action in secondarily affected leaves commencing in the pinnæ before any action had manifested itself in the primary pulvinus, in cases 5 and 6 we have discontinuous action along the axis as the result of the application of heat, and in Table XI we have numerous examples of a similar phenomenon as the result of section of the extremities of axes. Especially in these latter cases we see that in certain cases we have to deal, not merely with discontinuity in order of occurrence of action, but with absolute discontinuity of action due to certain intermediate parts failing to act at all when others both distal and proximal to them have acted in greater or less degree. A closely related phenomenon frequently presents itself to observation under certain circumstances in cases of heating axes or section of the extremities of axes where spreading action extends along the axes for a considerable distance but is confined to the primary pulvini alone. In such cases the limitation of action to the primary pulvini is readily explicable as the result of the relatively excessive strain there already alluded to, and the same holds good in regard to the numerous instances in which section of distal pinnules is followed by action confined to the injured pinna and the primary pulvinus. The cases of pure discontinuity in action in the pinnules of a pinna or the leaves on an axis are more difficult to explain, but, in the light of the facts which we have just been considering, it appears certainly more justifiable to ascribe the phenomena to differences of structural power, or in amount of strain in the different parts, than to totally inexplicable and undemonstrated differences in conductivity, irritability, or contractility in the protoplasm.

In dealing with the subject of discontinuity in action there is one thing more which calls for special note, and that is the frequency with which the secondary pulvini fail to act even where complete action has taken place throughout the whole of the rest of a leaf. This is specially the case in cases of action following section of the pinnules, for in such cases, under the conditions in which the experiments dealt with here were conducted, action in the secondary pulvini occurs so infrequently as to be almost exceptional. In cases of action due to the application of heat to pinnules, action in the secondary pulvini is generally well pronounced, but even here exceptions frequently present themselves. This is not the only difference in the phenomena attending heating as compared with section of the pinnules. A reference to the tables will show that premature action in the primary pulvinus is relatively very rare in experiments on heating, and that there is a distinct tendency to wider propagation of action in them than in cases of section. The phenomena of recovery, too, are different according to the exciting cause. In

cases of heating of the pinnules elevation of the petiole is the primary phenomenon of recovery; in cases of section expansion of the pinnules occurs first, and the pinnæ are more or less fully expanded long before the petiole has regained its erect condition, and the same order is followed in recovery after pure mechanically induced movement of the leaves. The precise causation of these differences is a subject calling for further investigation, and I would merely, in the meantime, suggest that it is probably to be found in variations in the amount of fluid discharged from the tissues in the different classes of cases, and in variations in rate of discharge, the phenomena in cases of section corresponding with the occurrence of rapid escape of a limited amount of fluid, those in cases of heating with slow, protracted escape of larger quantities.

The theses originally propounded having now all been considered in detail, and the evidence appearing to support them having been adduced, I have merely to add a few words in regard to a question which has more and more forced itself upon me in the course of working at the subject of the propagation of movement in *Mimosa pudica.* This question is—how far are the movements themselves due to anything more than purely mechanical agency; how far does any active contraction of protoplasm come into play to give rise to them; and how far are they not mere results of fluctuations in the fluid tension of the tissues? The data contained in Table XIII are very suggestive of questions of this nature. In the experiments detailed in this table the sun's rays were carefully focussed on a series of primary pulvini, the application being, as far as possible, confined to the upper surfaces. The 15 experiments registered were conducted on two successive mornings, but numerous other experiments at other periods have demonstrated that the results then obtained were not exceptional. In 8 cases of the 15, the primary phenomenon following the application was elevation of the petiole; in one case it was a rotatory movement; in only 6 was it depression. In the majority of cases in which elevation occurred it was followed by depression, but in two cases the elevation was not followed by depression, although it was followed by action in the pinnæ.

These phenomena of elevation are clear indices of the occurrence of loss of fluid so localised, at the outset at all events, as to cause relative weakening in the tissues of the upper half of the thickness of the primary pulvinus; that is weakening in the tissue directly affected, and, as this was the tissue which makes for depression, to lead to increased elevation of the petiole. The elevation was, as a rule, transitory and soon replaced by depression, because, as the loss of fluid continued, it extended to the tissues on the underside of the pulvinus and thereby re-established the normal potential relations of the opposed masses of tissue, the inferior and structurally weaker becoming naturally absolutely the weaker when loss of fluid had extended to it also. Such a phenomenon is, at all events, well calculated to raise a doubt as to whether the so-called irritable areas in the leaves are really specially irritable, or whether

they are not merely areas in which disturbances in the fluid tension of the tissues have special facility in giving rise to movements due to structural peculiarities and to relations to other masses of tissue. The areas of special irritability are ordinarily affirmed to lie in the under surface of the primary pulvinus, the inner surfaces of the secondary ones, and the upper surfaces of the pinnules and tertiary pulvini. But these are all areas in which structural peculiarities of the tissues and the mutual relations of various parts must inevitably favour the occurrence of movements as the result of fluctuations in fluid tension incapable of giving rise to movement in other parts in which such adjuvant agents are absent or are replaced by positively opposing ones, as they are in the upper portions of the primary pulvinus, in the outer parts of the secondary ones and in the under parts of the tertiary ones. Where negative fluctuations in fluid tension take place in the so-called irritable areas, they act in favour of the structurally stronger masses of tissue which are constantly striving to establish the passive or nocturnal position of the various parts; whereas in the other areas they act in direct opposition to them. The tendency to more certain and ready occurrence of movement as the result of influences calculated to give rise to negative fluctuations in the fluid content of the tissues, when acting on the so-called irritable areas than when acting elsewhere, can be accounted for on purely physical grounds, and does not necessarily imply the presence of any special irritability or contractility of the protoplasm of the parts. According to the theory that the occurrence of movements is due to mere physical causes, we can account for the distribution of so-called irritability. According to the theory that it is due to special functional properties in the protoplasm of the various masses of tissue, we cannot do so save by the aid of pure assumption.

Whether all the movements which occur in *Mimosa* ought to be regarded as mere mechanical results of fluctuations in the fluid tension, as the nyctitropic ones unequivocally are, remains an open question, but there are grounds for the belief that to a great extent, at all events, they are so. It appears probable that to a very great extent the so-called movements of irritation differ merely in degree, and not in kind, from common nyctitropic ones, the difference lying merely in the degree of rapidity with which the movements are carried out. In the case of the leaves of *Mimosa pudica*, just as in the case of leaves in which all conspicuous movements are of a purely nyctitropic character, the displacement of the various parts is due to the opposition of masses of tissue differing from one another in their structural strength and power of absorption of fluid, those which possess the greatest passive structural strength having the least capacity for absorption and *vice versâ*. Due to this the relative strength of the various masses differs at different times under the influence of different conditions, and corresponding changes take place in the position of the parts on which they work. During the night there is a general diminution in

the fluid content of the tissues and hence the structural stronger masses, although absolutely weaker then than during the day become relatively stronger, and therefore the nocturnal position of parts is always more or less that which they make for. Under the influence of light the structurally weaker masses attain their maximum of relative strength, because of the greater absorption of fluid which they are capable of due to the larger amount of active elements, and specially of chlorophyll containing elements which is present in them than in the opposed masses, and which determines excessive absorption either as a direct result of light stimulation, or as the result of the development of specially absorptive matters by the protoplasm under the influence of such stimulation. The position of the various parts is at any time one due to equilibrium between the opposing masses of tissue, and movements result whenever this equilibrium is disturbed by alterations in their fluid tension. In ordinary nyctitropic leaves facilities are not provided for the occurrence of rapid fluctuations of fluid tension in the tissues, and hence the movements are normally of a slow and insensible character only manifesting themselves under the prolonged influence of condition determining general changes in amount of fluid content of the entire plant. In the case of *Mimosa* the structural peculiarities in the opposing masses of tissue determining the position of the various parts are such as to permit of very rapid redistribution of large masses of fluid, and hence a possibility arises for the occurrence, not merely of movements of the ordinary nyctitropic type, but of rapid movements connected with fluctuations in fluid-content too slight and transitory to be capable of producing appreciable effects apart from such facilities. The equilibrium between the opposing masses of tissue in *Mimosa* is much more unstable than it is in common nyctitropic tissues due to the presence of structural peculiarities, and in connection with this we find corresponding differences in the character of the movements. The instability of diurnal equilibrium in *Mimosa* is further increased by the exceptionally high fluid tension, throughout the plant, which is maintained, in spite of the constant loss of large quantities of fluid, by the absorption of equally large quantities by the roots. In other words, the diurnal condition of the leaves in *Mimosa pudica* is determined by the equilibrium of opposing masses of tissue. But this equilibrium is extremely unstable, as it is only maintained as the result of extreme fluid tension in masses of tissue of very different structural power, in a system from which constant losses of fluid are taking place and in which the structural peculiarities of the parts directly concerned in maintaining the expansion of the leaves afford special facilities for the occurrence of rapid local redistribution of fluid. Under such circumstances we should expect to find that fluctuations in fluid tension incapable of giving rise to conspicuous movements in common nyctitropic leaves are capable of doing so here, and this we find to be actually the case. In fine, the position of expansion of the leaves of *Mimosa*

pudica is one of exceedingly unstable equilibrium dependent on the opposed tendencies of different masses of tissue which tend in one case to establish the nocturnal, in the other the diurnal, position of the various parts. The excessive instability of the equilibrium is due, first, to the extreme fluid tension on which it depends, and which is only maintained so long as there is a constant supply of fresh fluid added to the tissues to make good the constant losses due to excessive transudation, and, second, to the presence of structural differences in the opposed tissues specially facilitating the occurrence of diminutions in fluid tension in those which make for the diurnal position. The conditions are such that very slight fluctuations in fluid tension are necessarily adapted to give rise to extensive displacements of the various parts of the leaves, so that it appears doubtful whether it be necessary in any case to assume the occurrence of any active protoplasmic contraction in order to account for the motorial phenomena.

CALCUTTA;
The 14th April 1887.

TABLES.

TABLE I.—*General Table of Results of section of Distal Pinnules of Mimosa pudica.*

No. of Experiment.	Result.
1	Slow and irregular action in the other pinnules of the injured distal pinna; partial and irregular action in the other distal pinna; no further result.
2	Spreading action in the injured distal pinna; action in its pulvinus, and immediate action in the primary pulvinus; centrifugal action in the pinnules of the proximal pinna of that side of the leaf; no further result.
3	Spreading action in the pinnules of the cut distal pinna; action in the other distal pinna; action in the proximal pinna of the injured side of the leaf; no further result; no action in the secondary pulvini.
4	Spreading action in the pinnules of the injured distal pinna; action in one proximal secondary pulvinus; action in the primary pulvinus; no further result.
5	Commencing action in the pinnules of the injured distal pinna; action in the primary pulvinus; completed centripetal action in the injured [illegible], partial action in the other distal pinna and in the proximal pinn[illegible] the injured side; no further result.
6	Results as in No. 5.
7	Spreading action in the pinnules of the injured distal pinna; commencing action in the pinnules of the proximal pinna of the injured side of the leaf; action in the primary pulvinus, and commencing action in the opposite distal pinna; action of the other proximal pinna; no further result.
8	Results as in No. 7.
9	Partial spread of action along the injured proximal pinna; action in the primary pulvinus, and commencing action in the distal pinna of the injured side; partial action in the other distal pinna; no further result.
	The above experiments were carried out on various occasions during the rains.
10	*Leaf not yet reached by the sunshine.*—Very slow and incomplete action in the cut pinna, the pinnules of the outer third and those quite at the base acting imperfectly, whilst an intermediate groups of four pinnules on either side failed to move; no further result.

TABLE I.—*General Table of Results of section of Distal Pinnules of Mimosa pudica*—continued.

No. of Experiment.	Result.
11	*Leaf not yet reached by the sunshine.*—Very slow and partial action in the pinnules of the distal half of the pinna, and in one on one side of the middle of the proximal half; no further result.
12	*Leaf not yet reached by the sunshine; section involving the tip of the secondary petiole.*—Rapid, progressive action in the pinnules of the cut pinna, followed by immediate action in the primary pulvinus; no further result.
13	*Leaf and section as in No. 12.*—Immediate action of about six pairs of distal pinnules and of the primary pulvinus; pause; very slow, progressive action in the other pinnules of the distal half of the cut pinna; no further result.
14	*Leaf not yet reached by the sunshine; section involving tips of distal pinnules only.*—Very slow and partial action in the pinnules of the distal third of the cut pinna, and in some pinnules on one side at the base; no further result.
15	*Leaf not yet reached by the sunshine; section involving the tip of the secondary petiole.*—Imperfect action in all the pinnules of the cut pinna; no further result.
16	*Leaf in full sunshine; section involving tips of pinnules only.*—Spreading action in the pinnules of the cut pinna; action in the primary pulvinus; complete action in the pinnules of the other pinnæ; no further result.
17	*Leaf in full sunshine; section involving tip of secondary petiole.*—Action in the pinnules of the cut pinna; pause; action in the secondary and primary pulvini; complete action in the remaining pinnæ; action in the primary pulvinus of the first leaf above.
18	*Leaf and section as in No. 17.*—Spreading action in the pinnules of the cut pinna; action in the primary pulvinus; complete action in the other pinnæ; no further result.
19	*Leaf in full sunshine; section involving pinnules only.*—Spreading action in the pinnules of the cut pinna; action in the primary pulvinus; complete action in the remaining pinnæ; nothing more.
20	*Leaf and section as in No. 17.*—Spreading action in the pinnules of the cut pinna; pause; action in the primary pulvinus; complete action in the other pinnæ; no further result.
21	*Leaf and section as in No. 17.*—Spreading action in the pinnules of the cut pinna; pause; action in the primary pulvinus; complete action in the other pinnæ; no further result.

TABLE I.—*General Table of Results of section of Distal Pinnules of Mimosa pudica*—continued.

No. of Experiment.	Result.
22	*Leaf in full sunshine; section involving pinnules only.*—Spreading action in the pinnules of the cut pinna; action in the secondary pulvinus, and commencing action in the pinnules of the distal pinna of the same side of the leaf; action in the primary pulvinus; complete action in the remaining pinnæ; action in the primary pulvinus of the next leaf above; complete action in three of its pinnæ, and incomplete action in the fourth one; no further result.
	Experiments 10 to 22 were all conducted at an early hour on one morning, and very clearly show the effect of protection from, or exposure to, conditions favouring loss of fluid by evaporation. The morning was that of the 30th December 1886. It was mild and hazy, quite still, and with a drenching dew.
23	*Leaf not yet reached by the sunshine; section involving tips of pinnules only.*—Action in the first two or three pairs of pinnules; action in the primary pulvinus; progressive, slow, centripetal action in the pinnules of the cut pinna; imperfect action in the pinnules of the other pinnæ; no further result.
24	*Leaf not yet reached by the sunshine; section involving the tip of the secondary petiole.*—Spreading, centripetal action in the pinnules of the cut pinna; action in the primary pulvinus; imperfect action in the pinnules of the remaining pinnæ.
25	*Leaf exposed to direct sunshine; section involving the tips of the pinnules only.*—Complete, spreading action in that leaf and in the leaf next above.
26	*Leaf and section as in No. 25.*—Complete, spreading action in that leaf; no further result.
27	*Leaf and section as in No. 25.*—Complete, spreading action in that leaf, in one below, and in one above it.
28	*Leaf and section as in No. 25.*—Complete, spreading action in that leaf and in one leaf below it.
29	*Leaf exposed to direct sunshine; section involving the tip of the secondary petiole.*—Complete, spreading action in that leaf; no further result.
30	*Section involving the tip of the secondary petiole.*—Complete action in the leaf; no further results.
31	Section and results as in the previous case.
32	*A two-pinnaed leaf; section involving the tip of the secondary petiole.*—Complete, spreading action in that pinna; nearly complete action in the other one; no further result.

TABLE I.—*General Table of Results of section of Distal Pinnules of Mimosa pudica*—continued.

No. of Experiment.	Result.
33	*Leaf not yet reached by the sunshine.*—Action of two or three pairs of pinnules; action in primary pulvinus; slow, partial, centripetal action in the cut pinna; slow, centrifugal action in the rest of the pinnæ; no further result.
34	*Leaf in shade.*—Very slow, complete, centripetal action in the cut pinna; action in the primary pulvinus when the action in the cut pinna had almost reached the base; very slow, partial action in the other pinnæ; no further result.
35	*Leaf exposed to direct sunshine.*—Complete, spreading action in the cut leaf; partial action in one beneath; complete action in the first leaf above; action in the primary pulvinus of the third leaf above; very slow, partial action in its pinnæ; no further results.
36	*Leaf exposed to direct sunshine.*—Complete, spreading action in the cut leaf; no further result.
37	*Leaf exposed to direct sunshine.*—Result as in the previous case.
38	*Ditto* Ditto.
39	*Ditto* Ditto.
40	*Leaf in shade.*—Partial action in the cut pinna; slight action in the primary pulvinus; no further result.
41	*Leaf in shade.*—Action in the distal two-thirds of the cut pinna; no further result.
42	*Leaf in shade.*—Action in the cut pinnules; action in the primary pulvinus; slow, progressive, centripetal action in the pinnules in the distal third of the cut pinna; no further result.
43	*Leaf in shade.*—Slow, progressive, complete action in the cut pinna; no further result.
43	*Leaf in shade.*—Complete, progressive action in the cut pinna; long pause; action in the primary pulvinus; no further result.
44	*Leaf in shade.*—Action in the cut pinna; action in the primary pulvinus, and extreme depression; partial action in the remaining pinnæ; no further result.
45	*Leaf in shade.*—Action in the cut pinna; action in the primary pulvinus; no further result.

TABLE I.—*General Table of Results of section of Distal Pinnules of Mimosa pudica*—continued.

No of Experiment.	Result.
46	*Leaf exposed to direct sunshine.*—Complete, progressive action in the cut pinna; action in the primary pulvinus; complete action in the remaining pinnæ; no further result.
47	*Leaf exposed to direct sunshine.*—Results as in the previous case.
48	*Ditto* Ditto.
49	*Ditto* Ditto.
50	*Ditto* Ditto.
51	*Leaf exposed to direct sunshine.*—Complete action in the cut pinna; commencing action in the other distal pinna; action in the primary pulvinus; complete action in the remaining pinnæ.
52	*Leaf in shade.*—Partial action in the cut pinna; full action in the primary pulvinus; no further result.
53	*Leaf exposed to direct sunshine.*—Complete action throughout the entire leaf; no further result.
54	*Leaf in the shade and exposed to rain.*—Very slow and partial action in the cut pinna; action in the primary pulvinus; no further result.
55	*Conditions as in the previous case.*—Results as in the previous case.
56	*Conditions as in No. 54.*—Action in the cut pinnules; action in the primary pulvinus; long pause; very slow and partial action in the pinnules of the distal half of the cut pinna; no further result.
56	*Conditions as in No. 54.*—Results as in the previous case.
57	*Conditions as in No. 54; tip of one pinnule only cut.*—Slow, progressive, well-developed action in the pinnules in the distal half of the cut side of the pinna; very feeble, partial action in a few of the distal pinnules of the opposite side of the cut pinna; no further result.
57	*Conditions as in the previous case.*—Results as in the previous case.
58	*Leaf exposed to direct sunshine.*—Partial action throughout the entire leaf; no further result.
59	*Leaf exposed to direct sunshine.*—Complete action throughout the entire leaf; no further result.

TABLE I.—*General Table of Results of section of Distal Pinnules of Mimosa pudica*—continued.

No. of Experiment.	Result.
60	*Leaf exposed to direct sunshine.*—Complete action throughout the entire leaf; no further result.
61	*Ditto* ditto ditto.
62	Slow, gradual action of the entire leaf; no further result.
63	Partial action in all the pinnæ; no further result.
64	Almost complete action throughout the entire leaf; no further result.
65	Partial action in all the pinnæ, and action of the primary pulvinus; no further result.
66	Almost complete action throughout the entire leaf; no further result.
67	Action in the cut pinnules; long pause; action in the primary pulvinus, but depression of the petiole mechanically prevented; long pause; slow, partial, centripetal action throughout the cut pinna; no further result.
68	Action in the cut pinnules, and in one or two pairs immediately beneath them; long pause; action in the primary pulvinus; pause; centripetal action throughout the cut pinna; partial action in the remaining pinnæ; no further result.
69	*Leaf in the shade.*—Action in the cut pinnules; long pause; action in the primary pulvinus, but depression of the petiole mechanically obstructed; very slight action in two or three pairs of pinnules beneath the cut ones; no further result.
70	*Leaf exposed to direct sunshine.*—Partial action throughout the entire leaf save the proximal pinna of the uncut side; no further result.
71	*Leaf exposed to direct sunshine.*—Slow, complete action throughout the entire leaf; no further result.
72	*Leaf in shade.*—Spreading, incomplete action in all the pinnules of the cut pinna; incomplete action in the basal halves of two other pinnæ; no further result; primary pulvinus responded readily to direct impulse.
73	*Leaf in shade.*—Incomplete action throughout the distal half of the cut pinna; no further result.
74	*Leaf in shade.*—Incomplete action throughout the cut pinna; no further result.
75	*Leaf exposed to direct sunshine.*—Complete action in the leaf; no further result.

TABLE I.—*General Table of Results of section of Distal Pinnules of Mimosa pudica*—continued.

No. of Experiment.	Result.
76	*Leaf exposed to direct sunshine.*—Complete action throughout the leaf save in the tip of one pinna; depression of the petiole somewhat obstructed mechanically; no further result.
77	*Leaf exposed to direct sunshine.*—Complete action throughout the leaf save in one pinna; no further result.
78	*Leaf exposed to direct sunshine.*—Complete action throughout the entire leaf; no further result.
79	*Ditto* ditto ditto.
80	*Leaf exposed to direct sunshine.*—Complete action in the cut leaf; no further result.
81	*Ditto* ditto ditto.
82	*Ditto* ditto ditto.
83	*Ditto* ditto ditto.
84	*Ditto* ditto ditto.
85	*Ditto* ditto ditto.
86	*Leaf exposed to direct sunshine.*—Pause; action in three or four pairs of pinnules; action in the primary pulvinus; almost complete action throughout the rest of the leaf; no further result.
87	*Leaf exposed to direct sunshine.*—Centripetal action throughout the cut pinna; commencing centrifugal action in the other distal pinna; action in the primary pulvinus; complete action throughout the rest of the leaf; no further result.
88	*Leaf exposed to direct sunshine.*—Very irregular and partial action in that pinna; partial action in the other distal pinna and in the proximal pinna of the cut side of the leaf; no further result; primary pulvinus partially rigid.
89	*Leaf exposed to direct sunshine.*—Complete action in the cut pinna; pause; complete action in the primary pulvinus, and extreme depression; complete action in the other pinnæ; no further result.
90	*Leaf exposed to direct sunshine.*—Complete action in the cut pinna; commencing action in the other distal pinna; action in the primary pulvinus; complete action in the rest of the leaf; no further result.

TABLE I.—*General Table of Results of section of Distal Pinnules of Mimosa pudica*—concluded.

No. of Experiment.	Result.
91	*Leaf in shade and plant drenched with dew.*—Pause; centripetal action in six pairs of pinnules; pause; action in the fifth pair of pinnules beneath those which had previously acted; pause; action in the fifth pair below those which had last acted; no further action in the cut pinna or elsewhere; primary pulvinus readily responsive to direct impulse.
92	*Conditions as in No. 91.*—Pause; action in seven successive pairs of pinnules; partial action in the pinnules at the base of the pinna; spread of centripetal action along the distal part, but action not extending to the area of basal action; action of the primary pulvinus, and extreme depression; action in one or two pinnules on one side of the base of the other distal pinna; no further result.
93	*Conditions as in No. 91.*—Very slow and very incomplete action in the cut pinna; action in the primary pulvinus, and extreme depression; no further result.
94	*Conditions as in No. 91.*—Very slow action in the tip of the cut pinna; very slow action in the basal portion; slow, centripetal action in the central portion; action in the primary pulvinus, and extreme depression; no further result.
95	*Conditions as in No. 91.*—Results as in No. 94 save that several of the central pinnules of the cut pinna failed to act.
96	*Conditions as in No. 91.*—Action in the cut pinnules; pause; slight action in one or two pinnules at scattered intervals along the course of the cut pinna; no further result; primary pulvinus responding readily to direct impulse.
97	*Conditions as in No. 91.*—Action in the cut pinnules; action in the primary pulvinus; incomplete centripetal action in the cut pinna; no further result.
98	*Conditions as in No. 91.*—Fairly complete action throughout the cut pinna save in three pinnules at the base; no further result; primary pulvinus readily responsive to direct impulse.
99	*Conditions as in No. 91.*—Results as in No. 97.
100	*Conditions as in No. 91.*—Incomplete action throughout the cut pinna; no further result; primary pulvinus readily responsive to direct impulse.

A total of one hundred experiments, in only six of which there was any extension of movement beyond the injured leaf.

TABLE II.—*Showing Results of section of Distal Pinnules on mornings after a fall of Rain.*

No. of Experiment.	Result.
	These experiments were carried out on two successive mornings, those of the 20th and 28th March, a fall of rain having occurred on each of the previous evenings. The brake of the plant was not exposed to direct sunshine at the time of experiment, and the leaves were clean washed but nearly dry, there having been hardly any dew during the preceding nights. All the leaves were young ones.
1	Action in the cut pinnules; pause; action in the primary pulvinus; spreading action in the cut pinna; action in the base of the other distal pinna; long pause; partial and slow action throughout two other pinnæ, and slight action in the base of the third one; no further result; very rapid recovery.
2	Spreading action in the cut pinna; action in the primary pulvinus, and extreme depression; slow and partial action in the bases of two of the other pinnæ; no further result; very rapid recovery.
3	Very slow, spreading action in that pinna save in the basal pair of pinnules; no further result.
4	Very slow, partial action in the pinnules of the cut pinna save three basal ones; no further result.
5	Action in cut pinnules; pause; action in primary pulvinus; slow, almost complete, centripetal action in the cut pinna; no further result.
6	Slow, centripetal action in the cut pinna; action in the primary pulvinus, and extreme depression; slow, partial action throughout one other pinna; and very slow, very partial action in the basal two-thirds of another; no further result.
7	Action in the cut pinnules; and in one or two pairs beneath them; pause; action in the primary pulvinus; long pause; spreading centripetal action in the cut pinna; pause; slight action in the base of the other distal pinna; no further result; primary pulvinus readily responsive to mechanical impulse.
8	*Tip of one pinnule only cut.*—Action in that pair; pause; action in primary pulvinus, and full depression; long pause; very slow, partial action in the base of the other pinna (a two pinnaed leaf); no further result.
9	Action in the cut pinnules; pause; action in the primary pulvinus; very slow action in the pinnules of the cut pinna; slow, partial action in the other pinna (a two pinnaed leaf) commencing ere action had extended to the base of the cut one.
10	Slow, almost complete action in that pinna; pause; action in the primary pulvinus, and extreme depression; slow, partial action in two other pinnæ; no further result.

TABLE II.—*Showing Results of section of Distal Pinnules on mornings after a fall of Rain*—continued.

No. of Experiment.	Result.
11	Slow, spreading, complete action in the cut pinna; action in the primary pulvinus, and full depression; slow, incomplete action in two other pinnæ; long pause; very incomplete action in the base of the remaining pinna.
12	*Tip of one pinnule only cut.*—Action in that pair of pinnules; pause; action in the primary pulvinus, but depression only partial due to mechanical obstruction; pause; centripetal action in the outer half of the cut pinna; no futher result.
13	Action in the cut pinnules; long pause; very slow but almost complete action in that pinna; no further result; primary pulvinus readily responsive to direct impulse.
14	Results as in the previous case. After an interval, but before the first pinna had completely recovered, the distal pinnules of the other pinna (a two-pinnaed leaf) cut with the following results:—Pause; action in the primary pulvinus, and full depression; complete action in that pinna; no further result.
15	Action in the cut pinnules; action in the primary pulvinus, and full depression; complete centripetal action in the cut pinna; no further result.
16	Action in the cut pinnules; pause; action in the primary pulvinus, but depression incomplete due to mechanical obstruction; pause; complete, centripetal action in the cut pinna; no further results.
17	Pause; slow, spreading action in that pinna; pause; action in the primary pulvinus, and extreme depression; spreading centrifugal action in two other pinnæ, complete almost to the tips; no further result.
18	Action in the cut pinnules; pause; slow, centripetal action in the cut pinna; pause; conspicuous action in its secondary pulvinus; pause; action in the primary pulvinus, and almost full depression; imperfect centrifugal action almost to the tip of the other distal pinna; pause; slow, incomplete action in the base of the proximal pinna of the same side of the leaf as the cut pinna; no further result.
19	Long pause; very slow action in the cut pinnules; very slow, centripetal action in the distal half of the cut pinna; action in the primary pulvinus, but incomplete depression due to obstruction; pause; action of all the remaining pinnules on one side of the cut pinna save the two basal ones; no action in the six lowest pinnules of the other side; no further result.
20	Action in the cut pinnules; pause; rapid, complete centripetal action throughout the cut pinna; no further result. After an interval, and when the first pinna had fully expanded in its basal half, the tip of the pinnules of the other distal pinna were cut with the following results:—Action in the cut pinnules; pause; action in the primary pulvinus and full depression; pause; complete, centripetal action in the second pinna; pause; almost complete, centrifugal action in the expanded, basal portion of the first pinna; no further result.

The results of the experiments detailed in the present table are specially

significant when compared with those in the succeeding one. There is a general resemblance in the phenomena in both, just as there was a general resemblance in the conditions to which the plants were subject at the time of experiment. There are at the same time differences in details of action corresponding with details in the external conditions. When the experiments included in Table III were carried out, the amount of soil moisture and of water on the leaves was much greater than when those of the present table were conducted, and coinciding with this we find indications of diminished tendency to extension of action, and increased tendency to early action in the primary pulvinus. This will appear more clearly if the results in these respects are tabulated alone:—

Table II.—20 experiments.
Action extending to other pinnæ in 10 cases.
Premature action in the primary pulvinus in 8 cases.

Table III.—10 experiments.
Action extending to other pinnæ in 4 cases.
Premature action in the primary pulvinus in 7 cases.

The conditions present in the experiments of Table III implied greater supply of moisture and greater mechanical strain on the primary pulvinus than those present in the experiments of Table II, and these were accompanied by more localised action and a greater tendency to premature action in the primary pulvinus.

TABLE III.—*Showing Results of section of Distal Pinnules after a continuous period of heavy Rainfall.*

No. of Experiment.	Result.
	The experiments detailed in this table were conducted between 8 and 9 A.M. of the 30th March after a night of continued heavy rain. The morning was very cloudy, so that the brake of the plant had not been exposed to direct sunshine. No rain was falling at the time, but the leaves, which were widely expanded, were, as a rule, heavily loaded with drops of water. All the leaves experimented with were fully developed but young ones, with four pinnæ.
1	Action in the cut pinnules; pause; action in the primary pulvinus; long pause; very slow, partial action to near the base of the cut pinna; no further result.
2	Action in the cut pinnules; long pause; very slow and partial, centripetal action in the cut pinna in its outer three-fourths; action in the primary pulvinus, but depression mechanically partially obstructed; pause; centripetal, imperfect action in the pinnules of one side of the basal fourth of the cut pinna: no further result.

TABLE III.—*Showing Results of section of Distal Pinnules after a continuous period of heavy Rainfall*—continued.

No. of Experiment.	Result.
3	Action in the cut pinnules; long pause; action in the primary pulvinus; long pause; very slow, imperfect action in the distal two-thirds of the cut pinna; no further result.
4	Action in the cut pinnules; long pause; very slow, incomplete action in the distal two-thirds of the cut pinna; pause; action in one pinnule below; no further result.
5	Action in the cut pinnules; long pause; action in the primary pulvinus; pause; slow, incomplete action in the distal three-fourths of the cut pinna; no further result.
6	Action in the cut pinnules; long pause; action in the primary pulvinus, but depression somewhat obstructed; slow, incomplete, centripetal action throughout the cut pinna, and partial, very imperfect centrifugal action in one other pinna.
7	Action in the cut pinnules; long pause; action in the primary pulvinus; almost complete action in the cut pinna; slight, very imperfect action in one other pinna a little above the base.
8	Action in the cut pinnules; pause; action in the primary pulvinus, and full depression; long pause; very slow, imperfect action in the distal three-fourths of the cut pinna; long pause; imperfect action of the basal pinnules of one side of the cut pinna; no further result.
9	Action in the cut pinnules; long pause; action in the primary pulvinus; long pause; very slow, very imperfect action in the cut pinna and in one other pinna; no further result.
10	Action in the cut pinnules; long pause; very slow and exceedingly imperfect action in the distal two-thirds of the cut pinna; slow action in the primary pulvinus, and full depression; very imperfect action in the basal third of the cut pinna, and very slow, very imperfect action in one other pinna; no further result.

The phenomena presented in this series of experiments are just what ought to have occurred according to the view that alterations in fluid tension, and the degree of strain present in various parts in maintaining the expanded condition, are the essential determinants of the propagation of movements from one part to another of the plant. The plants were very moist, the supply of root moisture excessive, the atmospheric humidity high, and the leaves loaded with adherent water. Coinciding with these conditions there was very slow, imperfect, and limited action, and a great tendency to early action on the part of the primary pulvinus, action in it occurring in 7 out of the 10 cases as the first phenomenon after action in the cut pinnules.

TABLE IV.—Showing the Results following section of Pinnules at different points in Pinnæ.

No. of Experiment.	Result.
	A.—Section of tips of distal pinnules of distal pinnæ.
1	Action in that pinna; slight action in its secondary pulvinus; action in the primary pulvinus, but depression somewhat obstructed mechanically; no further result.
2	Action in that pinna; no further result.
3	Pause; action in the primary pulvinus; centripetal action in that pinna; centrifugal action almost to the tip of the other distal pinna; no further result.
4	Slow action in that pinna, imperfect towards the base; action in the primary pulvinus; slight action in the bases of two other pinnæ; no further result.
5	Progressive, complete action in that pinna; no further result; primary pulvinus readily responsive to mechanical impulse; re-expansion very rapid.
6	Progessive, complete action to nearly the base of that pinna; no further result; primary pulvinus readily responsive to mechanical impulse.
7	Pause; full action in the primary pulvinus; spreading, complete, centripetal action in that pinna; no further result.
8	Very slow and imperfect action in that pinna; no further result; primary pulvinus readily responsive to mechanical impulse.
9	Pause; action in the primary pulvinus; action in the cut pinna; no further result.
10	Slow and almost complete action in that pinna; pause; action in the primary pulvinus; no further result.
	B.—Section of tips of proximal pinnules of proximal pinnæ.
11	Pause; action in the primary pulvinus; slow, slight, imperfect action in the bases of both proximal pinnæ; no further result.
12	Pause; commencing centrifugal action in the base of that pinna; action in the primary pulvinus; completed centrifugal action in that pinna; incomplete action in the base of two, and complete action in the base of the third remaining pinna.
13	Pause; incomplete action in the base of that pinna; incomplete action in the basal halves of the other pinnæ; no further result; primary pulvinus readily responsive to mechanical impulse.

TABLE IV.—*Showing the Results following section of Pinnules at different points in Pinnæ*—continued.

No. of Experiment.	Result.
14	Commencing centrifugal action in that pinna; action in the primary pulvinus; completed action in the cut pinna extending nearly to the tip; long pause; centrifugal action almost to the tip of the remaining pinna (a two-pinnaed leaf).
15	Pause; action in that and the opposite secondary pulvinus; slow, spreading action in the bases of both proximal pinnæ; pause; slight action in the bases of both distal pinnæ; no further result; primary pulvinus rigid.
16	Long pause; slow, centrifugal action in the base of that pinna; pause; action extended almost to the tip; slow action in the basal half of the remaining pinna (a two-pinnaed leaf); no further result; primary pulvinus readily responsive to mechanical impulse.
17	Pause; very slow, imperfect action in the basal two-thirds of both pinnæ (a two-pinnaed leaf); no further result; primary pulvinus rigid.
18	Pause; slow, centrifugal action in that and the other proximal pinna; pause action in the primary pulvinus; slow, partial action in the other two pinnæ.
19	Slow, partial, imperfect action in that pinna; action in the primary pulvinus; slow, partial action in the remaining pinnæ.
20	Action in the primary pulvinus; imperfect action in that pinna; long pause; partial action in the basal two-thirds of the other pinnæ.
	C.—Section of tips of central pinnules of proximal pinnæ.
21	Pause; imperfect centripetal action in that pinna; pause; very imperfect centrifugal action in it; no further result; the primary pulvinus readily responsive to mechanical impulse.
22	Pause; centripetal action in that pinna; very imperfect centrifugal action in it; very slow, imperfect action in the basal halves of the remaining pinnæ; no further result; primary pulvinus readily responsive to mechanical impulse.
23	Pause; imperfect centripetal action; pause; very slow, imperfect centrifugal action; action in the primary pulvinus; imperfect action in the remaining pinnæ; no further result.
24	Pause; centripetal action in that pinna; centrifugal action in it; action in the primary pulvinus; incomplete action in the other pinnæ; no further result.
25	Action in the primary pulvinus; centripetal action in the cut pinna; very slow, centrifugal action in it; imperfect action in the other pinnæ; no further result.

TABLE IV.—*Showing the Results following section of Pinnules at different points in Pinnæ*—concluded.

No. of Experiment.	Result.
26	Pause; centripetal action in that pinna; long pause; very slow, centrifugal action in it; action in the primary pulvinus; slight action in the other pinnæ; no further result.
27	Pause; centripetal action in the cut pinna; imperfect, centrifugal action in it; action in the primary pulvinus; slight action in the remaining pinnæ.
28	Pause; centripetal action in the cut pinna; long pause; action in its secondary pulvinus; long pause; centrifugal action in the cut pinna; very slight action in the remaining pinnæ; no further result; primary pulvinus readily responsive to mechanical impulse.
29	Pause; centripetal action in the cut pinna; centrifugal action in it; action in the other pinna (a two-pinnaed leaf); action in the primary pulvinus; no further result.

This table consists of the results in a series of experiments carried out in a morning following a night in the early part of which there had been a heavy shower of rain. The morning was cloudless but slightly hazy, the sunshine had not at the time of experiment reached the brake of *Mimosa*, and the leaves were widely expanded, well-washed but relatively dry, the amount of adherent moisture being trifling as compared with that present after a normal dewy night. The results of the experiments are typical for plants under similar conditions. The amount of action in the leaves was almost in every case very limited, the action sometimes being confined to the cut pinna, sometimes extending to other pinnæ in greater or less degree, but leaving the primary pulvinus unaffected, and in no case was the action complete throughout the leaf. In 6 cases only did the primary pulvinus act immediately in sequence to the cut pinnules, but in 10 cases it acted before any of the uninjured pinnæ and in some of these before action in the cut pinna was completed. These results in regard to the period at which the primary pulvinus acted should be compared with those in Table VII, in which we have 10 cases, in 8 of which action in the primary pulvinus immediately succeeded action in the injured pinnules. This difference, as well as the generally-limited character of the action in the leaves, cannot be ascribed to any incapacity for action in these cases, for the contractile apparatus almost without exception responded fully to direct impulses. They are, however, just what the conditions under which the plants were at the time of experiment will account for. There had been a recent and abundant supply

of moisture, but the leaves were not weighted by it, and the direct sunshine had not yet impinged on the brake. There was an abundant supply of root moisture, slight evaporation, and an absence of extraneous strain on the primary pulvini coincident with very limited extension of action and delay in the action of the primary pulvini.

TABLE V.—*Results of Experiments on section of Distal Pinnules in Dry Leaves fully exposed to direct sunshine.*

No. of Experiment.	Result.		
1	Spreading and complete action in that leaf; no further result.		
2	Ditto	ditto	ditto.
3	Ditto	ditto	ditto.
4	Ditto	ditto	ditto.
5	Ditto	ditto	ditto.
6	Ditto	ditto	ditto.
7	Ditto	ditto	ditto.
8	Ditto	ditto	ditto.
9	Ditto	ditto	ditto.
10	Ditto	ditto	ditto.
11	Ditto	ditto	ditto.
12	Ditto	ditto	ditto.
13	Spreading almost complete action in that leaf; no further result.		
14	Ditto	ditto	ditto.
15	Spreading complete action in that leaf; action in the first leaf below.		

The results in this table contrast strongly with those in the preceding one. The difference is, however, quite in accordance with the difference in conditions present in this case. The experiments were here conducted on a bright, clear morning, with very warm sunshine and relatively dry air and after the brake

of the plant had been for some time exposed to strong, direct sunshine. Under such circumstances, there was much more complete and extensive action than under the conditions present in the case of the experiments of the preceding table, the cut leaves acting completely in 13 of the 15 cases, and action extending to a second leaf in one.

TABLE VI.—*General Table of Results of Application of Heat to the tips of Distal Pinnules.*

No. of Experiment.	Result.
	A.—Heat applied to tips of distal pinnules of distal pinnæ.
1	Spreading, centripetal action in that pinna; action in the primary pulvinus; action in the remaining pinnæ; action in the primary pulvinus alone of the second leaf beneath the heated one; action in the primary pulvinus of the first leaf below; action in the primary pulvinus of the first leaf above.
2	Spreading, centripetal action in the pinnules of that pinna; commencement of action in the other distal pinna; action in the primary pulvinus.
3	Spreading, centripetal action in that pinna; action in the primary pulvinus; action in the other distal pinna.
4	Spreading, centripetal action in that pinna; conspicuous action in the secondary pulvini; immediate action of the primary pulvinus; spreading, centrifugal action in the pinnules of the other pinnæ.
5	Spreading action in that pinna; pause; action in primary pulvinus; action in secondary pulvini and pinnules of the other pinnæ.
6	Spreading action in that pinna; action in the secondary pulvini; action in the primary pulvinus; spreading, centrifugal action in the other pinnæ.
7	Ditto ditto ditto.
8	Spreading action in that pinna; long pause; action in the secondary pulvinus of the proximal pinna of the same side and spreading, centrifugal action of the pinnules; action of the other distal secondary pulvini and of the primary pulvinus; spreading, centrifugal action in the pinnules of the second distal pinna; action in the other proximal pinna.
9	Spreading action in that pinna; action in the other distal secondary pulvinus; action in the primary pulvinus; action in the remaining secondary pulvini and pinnules.

TABLE VI.—*General Table of Results of Application of Heat to the tips of Distal Pinnules*—continued.

No. of Experiment.	Result.
10	Action in that pinna; strong action in all the secondary pulvini; action in primary pulvinus, and spreading, centrifugal action in the pinnules of the other three pinnæ; action in one leaf below and in two above.
11	Spreading action in the pinnules of that pinna; action in its secondary pulvinus and in the primary pulvinus; action in the remaining secondary pulvini and pinnules.
12	Spreading action in the pinnules of that pinna; strong action in all the secondary pulvini; spreading, centrifugal action in the pinnæ of the opposite side of the leaf, and action in the primary pulvinus; action in the proximal pinna of the same side; centrifugal action in the two leaves immediately above.
13	Action in that pinna; action in the secondary pulvini of the opposite distal pinna and of the proximal pinna of the affected side of the leaf; commencing action in their pinnules, and action in the primary pulvinus; action in the proximal pinna of the opposite side.
14	Spreading action in that pinna; pause; action in the primary pulvinus; action in the remaining pinnæ.
15	Spreading action in that pinna; action in the other distal pinna; commencing action in the proximal pinna of that side, and action in the primary pulvinus; action in the other proximal pinnæ.
16	Spreading action in that pinna; action in the primary pulvinus; action in the remaining pinnæ.
17	Action in the pinnules of that pinna; action in the secondary pulvini; action of the primary pulvinus, and commencing action in the other distal pinna; action in the proximal pinnæ.
18	Action in the pinnules of that pinna; action in the secondary pulvinus of that pinna; centrifugal action in the other distal pinna; commencing action in the proximal pinna of the affected side, and action in the primary pulvinus; action in the other proximal pinna.
19	Spreading action in the pinnules of that pinna; action in secondary and primary pulvini; action in the remaining pinnæ; action in the leaf immediately above.
20	Spreading action in the pinnules and secondary pulvinus of that pinna; action in the primary pulvinus; action in the other pinnæ.

TABLE VI.—*General Table of Results of Application of Heat to the tips of Distal Pinnules*—continued.

No. of Experiment.	Result.
	B.—Heat applied to the tip of a proximal pinna.
21	Spreading action in the pinnules of that pinna; action in its secondary pulvinus; action in the primary pulvinus, and spreading action in the distal pinna of the affected side; action in the opposite distal pinna.
22	Spreading action in the pinnules and secondary pulvinus of that pinna; commencing action in the distal pinna of that side; action in the primary pulvinus; action in the other pinnæ.
23	Spreading action in the pinnules of that pinna; action in all the secondary pulvini; action in the primary pulvinus, and commencing action in the pinnules of the distal pinna of the affected side; action in the other pinnæ.
24	Spreading action in the pinnules of that pinna; action of both secondary pulvini of that side of the leaf; action in the primary pulvinus; pause; action in the pinnules of the distal pinna of the affected side; action in the other pinnæ.
25	Spreading action in the pinnules of that pinna; action in its secondary pulvinus; action in the secondary pulvinus of the distal pinna of the same side of the leaf, and commencing action in its pinnules; action in the secondary pulvinus of the other distal pinna, and commencing action in its pinnules; action in the primary pulvinus; action in the other proximal pinna; long pause; action in the primary pulvinus of the leaf next below; long pause; partial action in its secondary pulvini and pinnules.
26	Spreading action in the pinnules of that pinna; long pause; action in the secondary pulvinus of that pinna, and immediate action in the primary pulvinus; no further result.
27	Spreading action in the pinnules of that pinna; strong action in its secondary pulvinus; action in the secondary pulvinus of the distal pinna of that side of the leaf; spreading action in its pinnules; action in the secondary pulvinus of the other distal pinna; commencing action in its pinnules, and action in the primary pulvinus; pause; action in the other proximal pinnæ.
28	Spreading action in the pinnules of that pinna; action in all the secondary pulvini and in the primary one; spreading action in the pinnules of the other pinnæ.
29	Spreading action in the pinnules of that pinna; long pause; action in all the secondary pulvini and in the primary one; spreading action in the pinnules of the remaining pinnæ.

TABLE VI.—*General Table of Results of Application of Heat to the tips of Distal Pinnules*—concluded.

No. of Experiment.	Result.
30	Results as in No. 28.
31	Spreading action in the pinnules of that pinna; pause; action in the secondary pulvinus of the affected pinna and in that of the distal pinna of the same side; commencing action in the pinnules of the latter pinna, and action in the primary pulvinus; action in the other pinnæ.
32	Spreading action in the pinnules of that pinna; action in its secondary pulvinus and in that of the distal pinna of the same side of the leaf; commencing action in the pinnules of that distal pinna, and action in the primary pulvinus; pause; action in the remaining pinnules of the first distal pinna, and action in the other pinnæ; action in one leaf next above.
33	Spreading action in that pinna; action in the remaining pinnæ successively from the injured side of the leaf to the other; no action in the primary pulvinus.
34	Spreading action in that pinna; action in all the secondary pulvini and in the primary one; action in the pinnules of the remaining pinnæ.
35	Slow and irregular action in that pinna; no further result.
36	Spreading action in that pinna; pause; action in that secondary pulvinus; action in the primary pulvinus, and commencing action in the distal pinna of that side; pause; action in the other pinnæ.
37	Spreading action in the pinnules; action in the secondary pulvinus of that pinna and in the primary pulvinus; pause; action in the remaining pinnæ.
38	Slow, spreading action in that pinna; action in its secondary pulvinus; action in the primary pulvinus; pause; slow, centrifugal action in the remaining pinnæ.
39	Results similar to those in No. 38 save that the secondary pulvinus acted before the basal pinnules.
40	Results similar to those in No. 38 save that the basal pinnules of the distal pinna of the same side of the leaf had begun to act before the primary pulvinus did so.

A total of 40 experiments, in only 6 of which was there any extension of movement beyond the primarily affected leaf.

TABLE VII.—*Showing Results of the Application of Heat to the tips of Distal Pinnules when the Plants are dry.*

No. of Experiment.	Result.
	All the experiments were conducted between 8 and 9 o'clock A.M. of the 8th April. The previous night had been a still cloudy one and little dew had fallen. The morning was still and cloudy, and the sun had not as yet emerged. The brake of Mimosa was perfectly dry, but the leaves in a state of fullest expansion No rain had fallen for more than a week previous to the date of experiment.
1	Complete action in that leaf; very long pause; complete action in the first leaf above; no further result.
2	Action in the affected pinna; convergence of the secondary pulvini; action throughout the other pinnæ; action in the primary pulvinus; pause; action in one leaf above.
3	Commencing action in the affected pinna; action in the primary pulvinus; complete action throughout the rest of the leaf; no further result.
4	Complete action in that leaf, the primary pulvinus acting immediately after the affected pinna; long pause; action of the primary pulvinus of the leaf next below; no further result.
5	Complete action in the affected leaf; long pause; complete action in the first leaf above and the second leaf below; long pause; complete but very slow action in the second and terminal leaf above; no further result.
6	Action throughout the affected leaf, but depression mechanically obstructed, and pinnular action, in all save the primarily affected pinna, incomplete; long pause; action in the primary pulvinus of the second leaf above; pause; action in one of its secondary pulvini; partial action throughout the greater part of the pinnæ; long pause; action in the pinnules of one of the distal pinnæ of the first leaf above the primarily affected one; pause; action in its primary pulvinus and remaining pinnæ; no further result.
7	Slow, almost complete action in the affected leaf; no further result.
8	Slow, almost complete action in the affected leaf; long pause; action in the first leaf above, commencing in the pinnæ and ultimately complete; very long pause; complete action in the second leaf above, commencing in the primary pulvinus; no further result.
9	Complete action in the affected leaf; action of the primary pulvinus, and incomplete action of the pinnæ of the first leaf above; action in the primary pulvinus, and incomplete action of the pinnæ of the first leaf below; very long pause; incomplete action in the second and terminal leaf above; no further result.
10	Complete action in the affected leaf; no further result.

TABLE VIII.—*Results of one morning's experiments on pure Mechanical Stimulation of Mimosa pudica.*

No. of Experiment.	Result.
	A.—Depression of the leaf caused by action of the primary pulvinus following pressure on the upper surface of the petiole.
1	Full depression; no further result.
2	Ditto ditto.
3	Ditto ditto.
4	Ditto ditto.
5	Ditto; slight action in the secondary pulvin .
6	Ditto; no further result.
7	Ditto ditto.
8	Ditto ditto.
9	Ditto ditto.
10	Ditto ditto.
	B.—Depression of the leaf caused by touching the inferior surface of the primary pulvinus.
11	Full depression; no further result.
12	Ditto ditto.
13	Ditto; slight action in the secondary pulvini.
14	Ditto ditto ditto.
15	Ditto; no further result.
16	Ditto ditto.
17	Ditto ditto.
18	Ditto ditto.
19	Ditto ditto.
20	Ditto ditto.

TABLE VIII.—*Results of one morning's experiments on pure Mechanical Stimulation of Mimosa pudica*—continued.

No. of Experiment.	Result.
	C.—Action in individual pinnules due to elevation or depression of their tips or touching the upper surfaces of their bases.
21	Action in that pinnule; no further result.
22	Ditto ditto.
23	Ditto ditto.
24	Ditto ditto.
25	Ditto ditto.
26	Ditto ditto.
27	Ditto ditto.
28	Ditto ditto.
29	Ditto ditto.
30	Action in that and the opposite pinnule.

TABLE IX.—*Results attending Mechanical Obstruction to the depression of the Petiole on action of the Primary Pulvinus. All the experiments carried out on one morning by section of distal pinnules.*

No. of Experiment.	Result.
	A.—Depression of the leaf due to action of the primary pulvinus mechanically obstructed.
1	Tips of distal pinnules cut off. The cut pinnules acted at once; pause; action in primary pulvinus; pause; very imperfect centripetal action in the cut pinna; no further result.
2	Procedure and results as in No. 1.

TABLE IX.—*Results attending Mechanical Obstruction to the depression of the Petiole on action of the Primary Pulvinus*—continued.

No. of Experiment.	Result.
3	A leaf with two large pinnæ. Action in cut pinnules; pause; action in primary pulvinus; very slow, partial action in 8 pairs of pinnules beneath the cut pair; no further result.
4	Action in the cut pinnules; pause; action in primary pulvinus; centripetal action in the distal and basal portions of the cut pinna; slight action in the central portion; no further result.
5	Action in the cut pinnules; action in the primary pulvinus; partial, centripetal action in the distal and basal portions of the cut pinna; no action in the central portion; no further result.
6	Slow, spreading centripetal action in the outer part of the cut pinna; action in the primary pulvinus; very slow and partial; centripetal action in the basal part of the cut pinna; no further result.
7	Action in the cut pinnules; action in the primary pulvinus; partial action in the distal and basal thirds of the cut pinna; complete action in the central third; no further result.
8	Almost complete centripetal action in the cut pinna; action in the primary pulvinus; no further result.
9	Action in the cut pinnules; pause; action in the primary pulvinus; almost complete, slow, centripetal action in the cut pinna; no further result.
10	Slow, progressive, complete centripetal action in the cut pinna; long pause; action in the primary pulvinus; partial, irregular, centrifugal action in another pinna; very long pause; slight, slow action in the basal part of another pinna; no further result.
11	Action in the cut pinna; action in the primary pulvinus; pause; action in one other pinna; no further result.
12	Action in the cut pinnules; pause; action in the primary pulvinus; partial and incomplete centripetal action in the cut pinna; action in the basal half of one other pinna; no further result.
	B.—Depression of the leaf due to the action of the primary pulvinus fully carried out.
13	A two-pinnaed leaf. Pause; spreading, centripetal action in the cut pinna; full depression; well pronounced action in the basal half of the other pinna.
14	Slow, almost complete action in that pinna; pause; full depression; no further result.
15	Action in the cut pinnules; slow, progressive, centripetal action in that pinna; full depression; almost complete, spreading, centrifugal action throughout the other pinnæ.

TABLE IX.—*Results attending Mechanical Obstruction to the depression of the Petiole on action of the Primary Pulvinus*—concluded.

No. of Experiment.	Result.
16	Slow, progressive, almost complete action in that pinna; full depression; action in basal half of the next pinna; no further result.
17	Slow, progressive action in that pinna; full depression; no further result.
18	Slow, progressive action in that pinna; pause; extreme depression; gradual, complete centrifugal action in the other pinnæ.
19	Slow, progressive action in that pinna; pause; full depression; almost complete, centrifugal action in the basal two-thirds of the other pinna.
20	Slow progressive, complete centripetal action in that pinna; pause; full depression; pause; slow, centrifugal action in basal halves of two other pinnæ.
21	Slow, progressive, complete action in that pinna; pause; extreme depression slow, centrifugal action in the basal two-thirds of the other pinnæ.
22	Ditto ditto ditto.
23	Slow, progressive, centripetal action in that pinna; pause; full depression; action in basal halves of the other pinnæ.
24	Ditto ditto ditto.

In the above table we have the results of twenty-four experiments conducted on the same morning on leaves under precisely similar circumstances save that in twelve of the cases depression of the petiole was mechanically obstructed or prevented, whereas in the remaining twelve it was fully carried out. In three of the first set action was manifested in other pinnæ than the cut one; in ten of the second set a similar phenomenon was present.

TABLE X.—*Results of Application of Heat to the axes of Mimosa pudica.*

No. of Experiment.	Result.
1	*Heating effected by means of coiling one extremity of a piece of copper wire round the axes and applying a spirit-lamp flame to the free extremity.*—Centrifugal action of all the leaves above the point of application; no action below.

TABLE X.—*Results of Application of Heat to the axes of Mimosa pudica* —continued.

No. of Experiment.	Result.
	Heating effected by the application of the tips of heated forceps.
2	*Heat applied to the axes close beyond a proximal leaf and far from the next distal one.*—Progressive centrifugal action along the whole course of axis. No action below point of application.
3	*Ditto* ditto ditto.
4	*Ditto* ditto ditto.
5	*Ditto* ditto ditto.
6	*Ditto* ditto ditto.
7	*Ditto* ditto ditto.
8	*Procedure as in the previous cases.*—Results as in the previous cases save that the primary pulvinus of the first leaf beneath the point of application acted.
9	*Ditto* ditto ditto.
10	*Forceps applied nearer inferior than superior leaf.*—Progressive complete action of all the leaves above; no action below.
11	*Application as in No. 10.*—Action in all the leaves above; no action below.
12	*Ditto* ditto ditto.
13	*An old woody axis with three leaves with rigid primary pulvini above the point of application of the forceps, which was immediately beyond the first inferior leaf.*—Action in the secondary pulvini and pinnules of the first leaf above; no action below.
14	*Procedure as in No. 10.*—Results as in No. 10.
15	*Ditto* ditto.
16	*Forceps applied very close to the inferior leaf.*—Action in the inferior leaf and in all the distal ones.
17	*Procedure as in No. 15.*—Results as in No. 15.
18	*Procedure as in No. 17.*—Action in the first leaf above occurred 17 seconds after application.

TABLE X.—*Results of Application of Heat to the axes of Mimosa pudica* —continued.

No. of Experiment.	Result.
19	*Procedure as in No. 17.*—First leaf above acted after an interval of 20 seconds; there was then a pause of one minute, followed by action in the second and third leaves above; no action in the leaf beneath, although the point of application was very close to it.
20	*Forceps applied very close to inferior leaf.*—Almost immediate action in the primary pulvinus alone of the inferior leaf; slow, progressive, complete action in all the leaves above.
21	*Application very close to the inferior leaf.*—Slow, centrifugal action in all leaves above; no action below.
22	*Ditto* ditto ditto.
23	*Ditto* ditto ditto.
24	*Ditto* ditto ditto.
25	*Application very close to base of inferior leaf.*—Very slow, protracted, centrifugal action in all the leaves above; the primary pulvini acted at long intervals, and the pinnæ and pinnules remained for long expanded; no action below.
26	Slow, progressive, centrifugal action in all leaves above; no action below.
27	*Application far from any superior leaf.—Experiment just after heavy rain.* Spreading, centrifugal action in the primary pulvini of all leaves above; slight action in secondary pulvini and pinnules; no action below.
28	*Application very close to base of inferior leaf.*—Spreading, centrifugal action in all the leaves above; action in primary pulvinus, and slight action in pinnæ of leaf next below.
29	*Application as in No. 28.*—Action in the leaf next above; no further result.
30	*Application as in No. 29.*—Action in the pinnæ of the two next leaves above; no action in their primary pulvini or elsewhere.
31	*The two leaves next above the site of application had each a young axillary leaf.*—Action in these young leaves; no further result.
32	*Application as in No. 29.*—Action in axillary leaf of first old leaf above; long pause; action in axillary leaf of next superior leaf; long pause; action in axillary leaf of first inferior leaf; pause; action in primary pulvinus of first old leaf above the site of application.

TABLE X.—*Results of Application of Heat to the axes of Mimosa pudica* —continued.

No. of Experiment.	Result.
33	*Application as in No. 29, the points of the forceps almost touching the pulvinus of the leaf next below.*—Slow action in first two leaves above; no action below.
34	*Application as in No. 29.*—Very long pause; action in the primary pulvinus of leaf next above; very long pause; commencing action in the pinnæ of the first leaf, and action in primary pulvinus of the next leaf above; pause; action in the pinna of the second leaf; no action below.
35	*Application as in No. 29.*—Long pause; action of leaf next above; very long pause; action in terminal leaf of axis separated by six internodes from the previous leaf; action in the leaf below the terminal one; pause; action in leaf above that one which acted first; no further action.
36	*Application as in No. 29.*—Pause; action in leaf next above; short pause; action in leaf next below; very long pause; action in primary pulvinus of second leaf above site of application; long pause; action in its pinnæ; no further result.
37	*Forceps very strongly heated.*—Almost immediate action in leaf next below; long pause; action in primary pulvinus of first leaf above; pause; progressive, centrifugal action in its pinnæ; very long pause; action of the third leaf above the site of application; partial and slow action in pinnæ of the second leaf above the site of application; no further result.
38	*Application as in No. 29.*—Action in leaf next above; action in leaf next below; action of the second leaf beneath that (the intermediate leaf was at a rooted node); action in the first leaf of the axillary shoot of the leaf above the point of application; no action in the second leaf above, which was situated at a rooted node.
39	*Application as in No. 29.*—Action in all the leaves above the point of application; no action below.
40	*Application as in No. 29.*—Action in fourteen leaves on axis and shoots above, the primary pulvini alone acting in the more distal ones; no action below.
41	*Application immediately above the inferior leaf.*—Slow, progressive, centrifugal action in the primary pulvini of all the leaves above; the secondary pulvini and pinnules only acted in some cases, and in these after long intervals; no action below.
42	*In this experiment the flame of a wax match was applied direct to the axis.*—Action in four leaves above; no action in the fifth and terminal one; no action below.

TABLE X.—*Results of Application of Heat to the axes of Mimosa pudica* —continued.

No. of Experiment.	Result.
43	*Sun's rays focussed by a lens on the axis close to the inferior leaf and about two inches from the one next above.*—Spreading, centrifugal action in all the leaves above; no action below.
44.	*Application as in No. 43, the nearest distal leaf being about 3 inches from the site of application.*—Action in all distal leaves; no action below. In both 43 and 44 the first inferior leaf responded readily to direct stimulation, and in both the effect on the axis at the site of application was to cause exudation of a drop of fluid, but no visible discolouration.
45	*Application as in No. 44.*—Exudation of fluid; action in all leaves above; no action below.
46	*Application as in No. 45.*—Exudation of a drop of fluid; action in all leaves above; action in two leaves below.
47	*Application as in No. 46, close to inferior leaf and 1·5 inches from the superior one.*—No exudation; action in four leaves above; no action below.
48	*Application as in No. 47.*—Slight discolouration; no exudation; action in all the distal leaves; action in the leaf next below; no further action.
49	*Application as in No. 48.*—Action in three leaves above; no action below.
50	*Application as in No. 49.*—Visible exudation of a small drop of fluid; action in one leaf above; no action below.
51	*Application as in the previous cases, but about midway between the superior and inferior leaves.*—Slight discolouration; no visible exudation; action in all nine distal leaves; no action below, although all the leaves readily responsive to direct stimulation.
52	*Application as above, but close to the inferior leaf and about 1·5 inches from the superior one.*—No visible discolouration or exudation; action in all distal leaves; action in one leaf below.
53	*Application as above*—Discolouration and escape of fluid; action in four leaves above; no action below.
54	*Application as above.*—Discolouration and escape of a large drop of fluid; centrifugal action in six leaves above; no action below.
55	*Application as above, close to the inferior leaf.*—Discolouration, but no visible exudation; action in four distal leaves; slow action in first inferior leaf.

TABLE X.—*Results of Application of Heat to the axes of Mimosa pudica* —continued.

No. of Experiment.	Result.
56	*Application as above, midway between inferior and superior leaves.*—Slight discolouration; action in four distal leaves; no action below.
57	*Application as above, close to the inferior leaf and about 1·5 inches from the next superior one.*—No exudation; successive centrifugal action in all eight distal leaves; no action below, although the inferior leaf was readily responsive.
58	*Application as in No. 57.*—No exudation; action in all seven distal leaves; no action below; inferior leaf readily responsive.
59	*Application as in No. 58.*—Centrifugal action of all distal leaves; action in two leaves below; discolouration; no visible exudation.
60	*Application as in No. 59, close to the inferior leaf and about 1 inch from the superior one.*—No discolouration; no exudation; action in four leaves above, consisting of partial action of the primary pulvini, and slight action of pinnules; no action below; inferior leaf readily responsive to direct influences.
61	*Application as in previous experiments near the inferior and distant from the superior leaf.*—Action in the inferior leaf, and spreading centrifugal action in all the distal leaves; discolouration, and visible exudation of a large drop of fluid.
62	*Application as in No. 61, close to the inferior leaf and about 1·5 inches from the superior one.*—Discolouration; no exudation; progressive, slow, centrifugal action in all distal leaves; no action below.
63	*Application in No. 62, about 0·75 inches from leaf next below and 4 inches from leaf next above.*—Discolouration, and slight exudation; centrifugal action in all eleven distal leaves; no action below.
64	*Application as in No. 63, about 0·5 inches from the inferior and 1·75 inches from the superior leaf.*—Slight discolouration; no visible exudation; action in three first leaves above; no action below.
65	*Application as in No. 64, on a strong, hard axis, close to an inferior leaf and far from the distal one.*—No visible discolouration or escape of fluid; action in several leaves above; no action below.
66	*Application as in No. 65, about 0·5 inches from next leaf below and 13 inches from leaf next above.*—At one and a half minutes from the cessation of the application the leaf below and the two first leaves above acted; at two minutes the third leaf above the site of application acted; at 2·25 minutes the fourth and terminal leaf acted. The axis was a hard and dry one, and the application caused discolouration, but no exudation.

TABLE X.—*Results of Application of Heat to the axes of Mimosa pudica* —concluded.

No. of Experiment.	Result.
67	*Application as above, about 0·25 inches from leaf next below and 3 inches from leaf next above.*—The axis a strong, woody one; slow, progressive, centrifugal action in all distal leaves; long pause; action in the leaf next below; no further action.
68	*Application as above.*—Discolouration and slight exudation; action in all eight distal leaves; action in first leaf below when centrifugal action had almost reached the extremity of the axis; no further action.

A total of 68 experiments. In all of them centrifugal, propagation occurred, and in 50 centrifugal propagation only was present. In the 18 cases where phenomena of centripetal propagation was present, it was very limited in amount, in no cases advancing beyond the two nearest leaves. Of the total 68 experiments, 41 were carried out in the period from August to December, and 27 from December to March, and each of these groups furnished 9 cases of centripetal propagation. The phenomenon of centripetal propagation would from this seem to occur more frequently during dry than moist periods.

TABLE XI.—*Results of section of Tips of Axes in Mimosa pudica.*

No. of Experiment	Result.
	The tips of axes gently cut off by means of a sharp scalpel or pair of scissors.
1	Action in first four leaves beneath the tip· no action in the next three leaves action in the five following leaves.
2	Exudation of a large drop of fluid; long pause; action in leaf next below.
3	Exudation; long pause, action in two leaves next below.
4	Action gradually propagated centripetally along the axis as far as it was traceable.

TABLE XI.—*Results of section of Tips of Axes in Mimosa pudica* —continued.

No. of Experiment.	Result.
5	Results as in the previous experiment.
6	No result. The axis was a dry, hard one.
7	Progressive, centrifugal action in nine leaves below.
8	A long pause ; action in first leaf below.
9	Progressive, gradual, centripetal action in ten leaves below, *i.e.*, along entire course of axis traceable.
10	Action in first leaf below ; long pause ; irregular action along entire course of axis traceable ; some leaves acting, others situated at various points failing to act.
11	Very long pause ; action in first leaf below.
12	Progressive action of five leaves situated at intervals along the axis.
13	Very long pause ; action in the first leaf below.
14	Long pause ; action in the first leaf below.
15	Successive action in the three upper leaves.
16	Irregular action along the axis as far as traceable.
17	Regular centripetal action along all of the axis traceable, including nine leaves.
18	Irregular action along all of the axis traceable.
20	Ditto ditto.
21	Very long pause ; action in first inferior leaf.
22	Very long pause ; irregular, centripetal action along the axis.
23	Long pause ; action of superior leaf.
24	Ditto ditto.
25	Long pause ; regular centripetal action along the axis.
26	Pause, irregular, centripetal action along the axis.

TABLE XI.—*Results of section of Tips of Axes in Mimosa pudica* —continued.

No. of Experiment.	Result.
27	Regular, centripetal action along the axis so far as traceable.
28	Exudation of a large drop of fluid; pause; action in the third, fourth, fifth, and sixth leaves from the tip; no action in the first and second; no action in the seventh; action in the eighth; no action in the ninth; action in the tenth.
29	Exudation; pause; action in the second, third, fourth, fifth, and sixth leaves below; action in the ninth and tenth leaves; action in the first leaf; no action in the seventh and eighth leaves.
30	Exudation; pause; action in the second, third, fourth, fifth, sixth, and seventh leaves below; action in the first leaf; action in other leaves successively along the axis so far as traceable.
31	Action in fourth, fifth, and sixth leaves below.
32	Exudation of a very large drop; pause; centripetal action of all leaves successively along the course of the axis so far as traceable.
33	Exudation of a large drop; successive centripetal action in the primary pulvini only of eight leaves below.
35	Exudation; pause; action in third, fourth, fifth, and sixth leaves below; action in first leaf below; action of several leaves successively at wide intervals along the axis. The primary pulvini alone acted in some leaves, whilst in others complete action took place.
36	Exudation; pause; action in third, fourth, fifth, seventh, eighth, and ninth leaves; action in first leaf; long pause; action in second leaf. The primary pulvinus alone acted in most of the leaves.
37	Exudation; action of first, second, third, fourth, sixth, eighth, and ninth leaves. The primary pulvinus alone acted in most cases.
38	Action in fourth leaf below; action in third leaf; progressive centripetal action along the course of the axis; long pause; action of first leaf.

A total of 38 cases, demonstrating the possibility of very extensive centripetal propagation under certain conditions, and also showing the frequence with which the phenomena of movement take place irregularly along the axis.

TABLE XII.—*Showing Results of section of Distal Pinnules in young heavy Leaves.*

No. of Experiment.	Result.
1	Action in the cut pinnules; pause; action in the primary pulvinus; pause; action in the pinnules of that pinna; no further result.
2	Action in the cut pinnules; pause; violent and extreme action in the primary pulvinus; pause; centripetal action in one or two distal pinnules of the cut pinna; no further result.
	The other pinnules responded readily to mechanical impulses.
3	Action in the cut pinnules; pause; action in the primary pulvinus; spreading, centripetal action in the cut pinna; pause; nearly complete; action in the other distal pinna; no further result.
4	Action in the cut pinnules; pause; progressive action in the cut pinna; pause; action in the remaining pinnæ; action in the primary pulvinus.
5	Action in that pinna only.
6	Pause; action in the primary pulvinus; action in the distal two-thirds of the cut pinna; pause; action in the basal third; no further result.
7	Pause; action in the primary pulvinus; action in the pinnules of that pinna; no further result.
8	Results as in No. 7.
9	Ditto.
10	Ditto.

This table illustrates two points very clearly—the discontinuity of action under certain conditions, and the limitation of action under the influence of others. All these experiments were conducted between 7 and 8 o'clock of a warm, moist, still morning, on leaves which had not yet been exposed to direct sunshine and which were loaded with moisture. They were all large, young leaves, and in the majority of cases the weight of the pinnæ obviously strained on the primary pulvinus. Under these conditions there was a special reason why any loss of fluid should tell with special effect on the primary pulvinus, and at the same time a reason for only limited loss of fluid. The result ought to be specially rapid action in the primary pulvini and only limited action elsewhere, and such results were actually present, as the table shows.

Action in the primary pulvinus preceding centripetal action in the cut pinna appears to be the normal phenomenon under certain conditions. It may be looked for as almost certain to occur in young, heavy leaves, in which, from the position and direction of the petiole, a special strain is evidently exerted on the primary pulvinus in maintaining the erect position. In old heavy leaves, specially if loaded with dew or rain, similar phenomena frequently manifest themselves. They do not, however, occur with such constancy as in the young leaves. This is to be credited to the alteration in the character of the pulvinar tissues accompanying increased age. In the leaves of mimosa pudica the tissue of the under-half of the primary pulvinus is relatively weakest when the leaves arey oung and becomes gradually stronger and more resistant with increasing age. So much does this take place in certain cases that it is not uncommon to meet with old but otherwise healthy leaves in which the primary pulvinus has become rigid and in which accordingly petiolar depression is impossible. This increase in strength in the normally weakest tissue with increasing age is not peculiar to the pulvini of *Mimosa pudica*, much more conspicuous examples of it are present in other plants. For example, in *Bauhinias* and in *Albizzia Lebbek* the young leaves exhibit extreme nyctitropic movements which gradually diminish and ultimately absolutely disappear with increasing age and thickening and rigidity of the primarily passively weaker portions of the pulvinar tissues.

TABLE XIII.—*Results of focussing the Sun's rays on the upper surfaces of the primary Pulvini of Mimosa pudica.*

No. of Experiment.	Result.
1	Depression of the petiole.
2	Extreme elevation of the petiole, followed by depression.
3	Depression of the petiole.
4	Rotation of the petiole.
5	Depression of the petiole.
6	Strong elevation, followed by depression.
7	Strong direct elevation, followed by strong direct depression.
8	Elevation of the petiole.

TABLE XIII.—*Results of focussing the Sun's rays on the upper surfaces of the primary Pulvini of Mimosa pudica*—continued.

No. of Experiment.	Result.
9	Depression of the petiole.
10	Ditto.
11	Strong elevation; a pause; action in the pinnæ; nothing more.
12	Depression of the petiole.
13	Strong elevation, followed by action in the pinnæ, and depression of the petiole.
14	Elevation; a pause; action in the pinnæ; nothing more.
15	Elevation; a pause; depression.

A total of 15 experiments tried on two successive mornings and in which phenomena of elevation manifested themselves in nine instances.

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